AMATEUR'S PRACTICAL AID' SERIES

ELECTRICAL APPARATUS for AMATEURS

WARD LOCK & BOWDEN LIMITED

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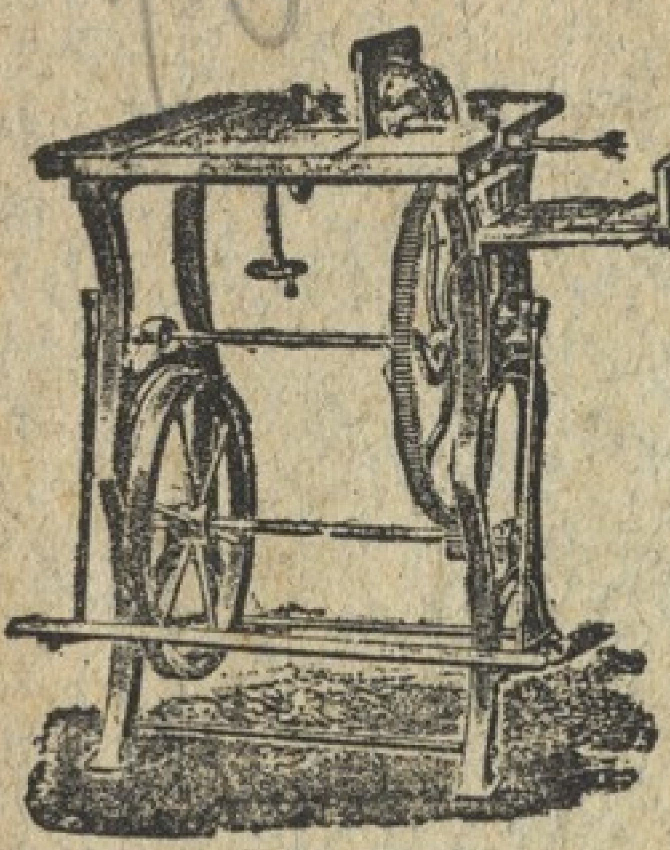
ELECTRICAL APPARATUS for AMATEURS

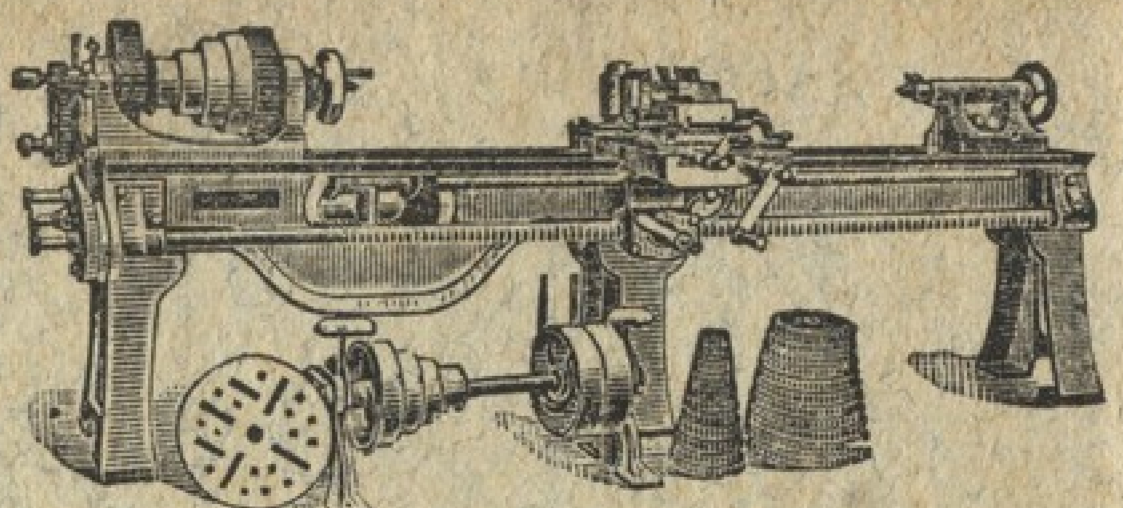
How I Made my Telephones

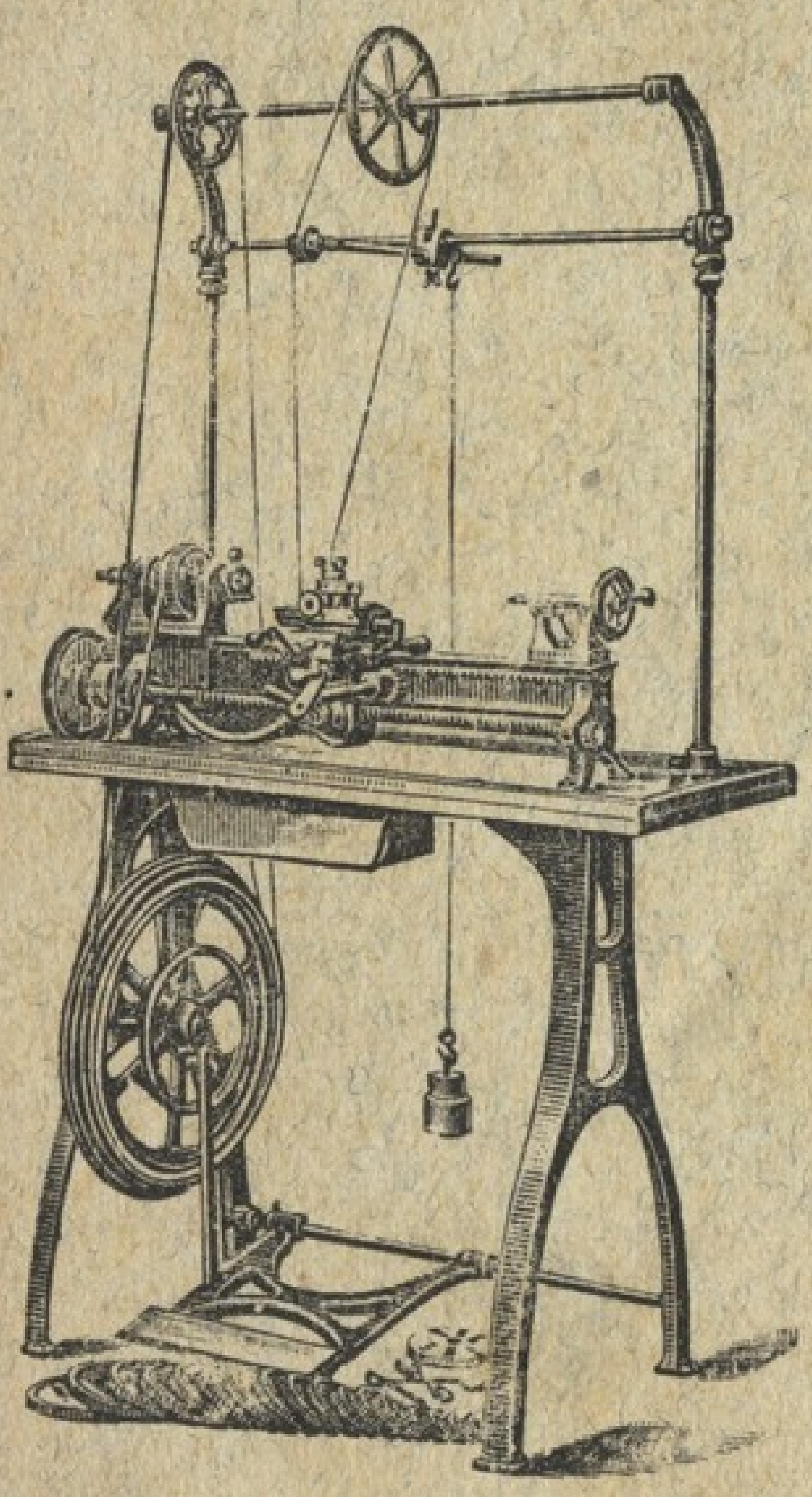
The Domestic Electric Light

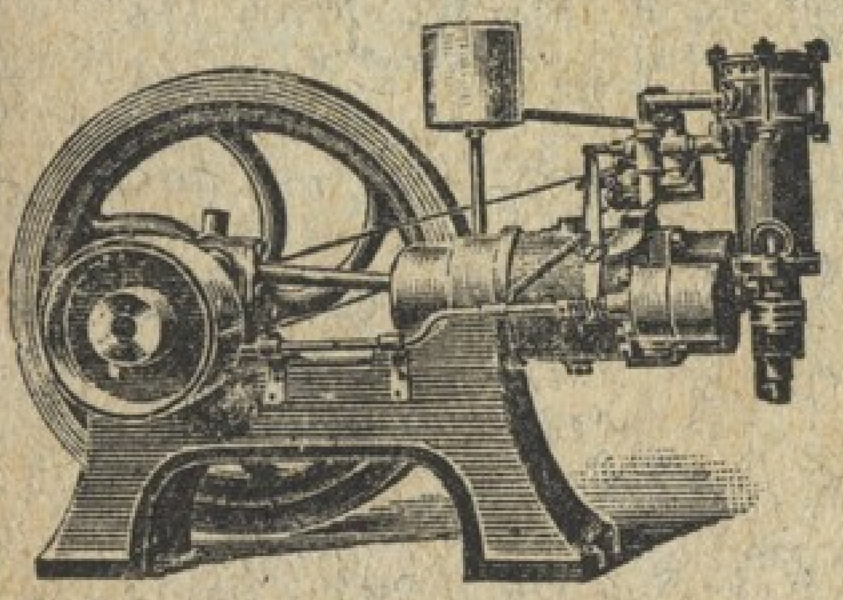
Electrical Machines

How I Built My First Coil









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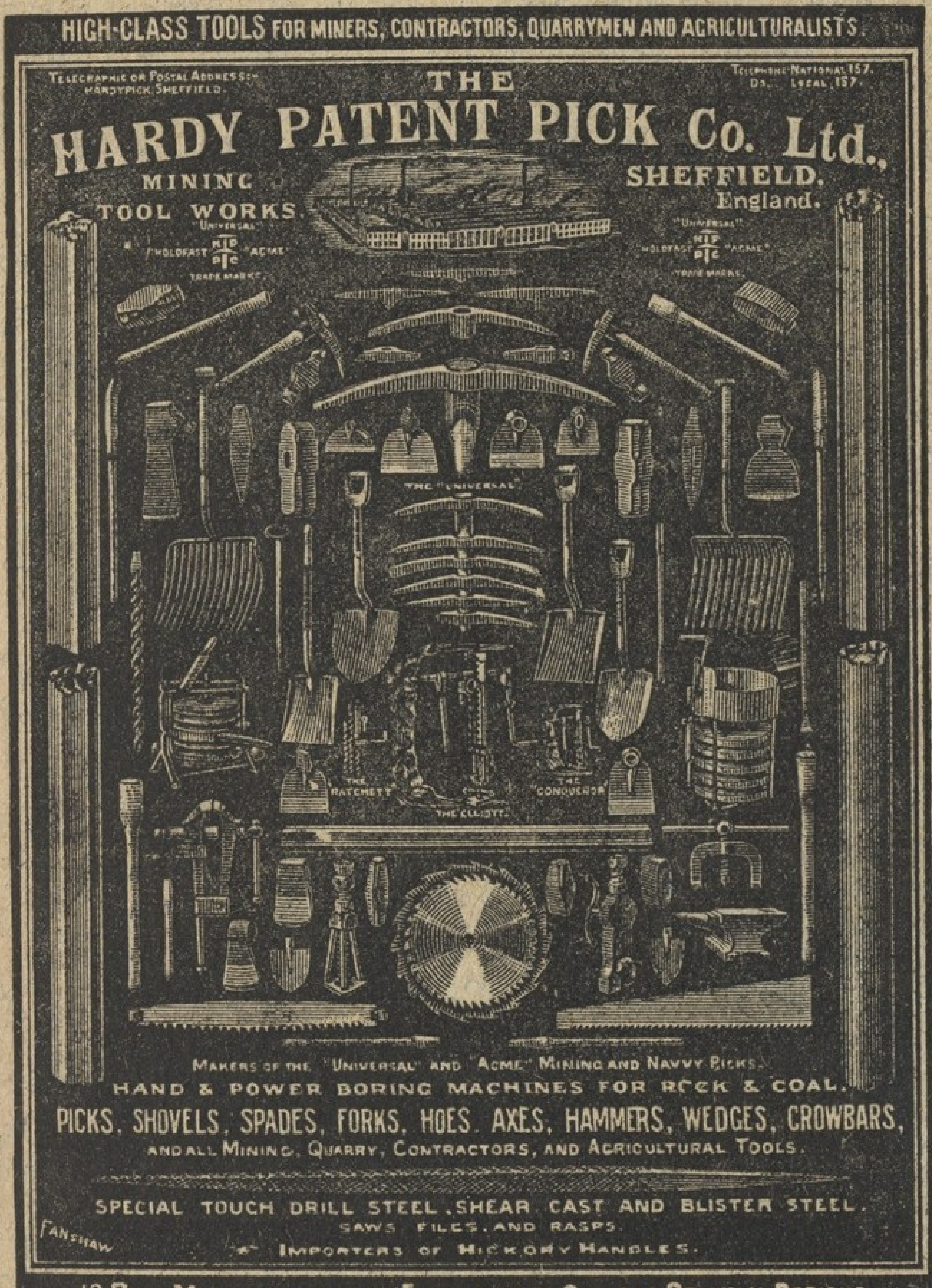

Arthur R. Goode

A R Goode

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ELECTRICAL APPARATUS FOR AMATEURS.

WARD, LOCK & BOWDEN'S

AMATEURS' PRACTICAL AID SERIES.

ELECTRICAL APPARATUS FOR AMATEURS.

IN FIVE PARTS.

Part I.

How I Made my Telephones.

BY G. H. SAYER.

Part II.

The Domestic Electric Light.

BY GEORGE EDWINSON.

Part III.

Magneto-Electric Machines, etc.

BY GEORGE EDWINSON.

Part IV.

A Cylindrical Electrical Machine.

BY C. J. CLARK.

Part V.

How I Built my First Coil.

BY R. WILLIAMS.

Illustrated with Numerous Explanatory Sketches and Diagrams.

EDITED BY

FRANCIS CHILTON-YOUNG,

Author of "EVERY MAN HIS OWN MECHANIC," "THE HOUSE AND ITS FURNITURE," *and Editor of* "AMATEUR WORK," *First Series of Seven Volumes.*

WARD, LOCK & BOWDEN, LIMITED,

LONDON: WARWICK HOUSE, SALISBURY SQUARE, E.C.

NEW YORK AND MELBOURNE.

1895.

PREFACE.

EVER since Electricity was first pressed into the service of man, and its wonderful powers and docility as an agent for effecting a wide variety of purposes were clearly demonstrated, it seems to have possessed an attraction for amateurs unequalled by any influence that leads the unskilled to try their hand at making and contriving, except that of the very general desire to handle the workman's tools and set about wood-working, or the wish that is evinced by so many to make any kind of instrument, from a whistle to an organ, from which sound can be elicited. The mania or "fever," as it is sometimes called, that urges men to devote the whole of their spare time to the prosecution of any hobby, and which is usually found to abate after a time, still continues unabated in the case of amateurs who would become electricians, and hence the inclusion of the present volume in the AMATEURS' POPULAR AID SERIES, as a companion to that on the construction of "Electric Bells" and "Electro-Plating at Home," which formed the preceding volume of the series.

In this volume, under the general title of "ELECTRICAL APPARATUS FOR AMATEURS," five descriptive tractates on the construction of as many electrical appliances for home use have been gathered and grouped together, and it will be found that these embrace instruction on transmission of sound by electric means, lighting, the production of curative influences by magneto electricity, the production of the electric fluid, and the mode of building a small induction coil. In no case, it is true, is much advance made beyond the threshold, or first stepping stones of and to the science; but the instructions are in every case such as will sufficiently whet the appetite of the neophyte to induce him to penetrate further into the mysteries of the subtle science in which he desires to become a master.

In the first of these Mr. G. A. SAYER deals with transmission of vocal sounds from one part of the house to another by means of a

simple telephone of his own contrivance. The appliances required in the construction of the machine are either easily obtained or easy to make ; and if the instructions given are carefully noted and implicitly followed, the home electrican will have no difficulty in saying and showing to any friend, as Mr. Sayer has said and shown to us, this is "HOW I MADE MY TELEPHONES AND GOT THEM TO WORK IN MY HOUSE." And more than this, he may be equally successful in lighting up any part of his house or workshop with the electric light if he will follow as carefully and implicitly the instructions given by Mr. GEORGE EDWINSON in the second part, on the steps that must be taken, first to make and then to set in action "THE DOMESTIC ELECTRIC LIGHT."

Third in point of order comes short and simple teaching on the mode and method to be followed in making a small MAGNETO-ELECTRIC MACHINE for MEDICAL PURPOSES of sufficient power to relieve pain in many a painful disorder to which flesh is heir, also from the pen of Mr. GEORGE EDWINSON. Next comes an equally interesting account by Mr. C. J. CLARK of the successive steps that he adopted in order to put himself in possession of a machine that many who have no thought of becoming adepts in electric science would like to have, if only for experimental purposes at social evening gatherings, and whose construction he exhibits in detail under the title, "HOW TO MAKE A CYLINDRICAL ELECTRICAL MACHINE." Lastly, though many will by no means consider it least in importance, comes Mr. R. WILLIAMS' interesting account of his first experiences in making induction coils, under the assuring heading, "HOW I BUILT MY FIRST COIL." We are told that what man has done man can do, and it is improbable that any will fail to do what Mr. Williams has done if they follow his instructions with the care and precision that the subject demands.

Just a word as to *prices* named herein. With regard to those that prevailed when the papers given were first written and the essayists made their first attempts at construction and manufacture, they are retained that readers may learn the difference in them when the demand was small, and the present time when the demand is large and supply has increased in a corresponding ratio.

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PART I.

HOW I MADE MY TELEPHONES.

HOW I MADE MY TELEPHONES,

AND GOT THEM TO WORK IN MY HOUSE.

CHAPTER I.

MAKING THE PARTS OF THE TELEPHONE, AND PUTTING THEM TOGETHER.

Introduction—Professor Bell's telephone—Close relation of magnetism and electricity—Influence of magnets on surrounding atmosphere—Action of voice on disc of telephone—Action of magnet on disc—Principal parts of telephone—Course of procedure indicated—The magnet and its cost—Case or holder—How to make the case—Fitting in the magnet—The box—Suitable box for purpose in view—Holes in top and bottom—Completion of case—Attachment of case and box—Reel or bobbin—Fitting magnet to reel—The wire—Quantity required—Its cost and gauge—Attachment of wire to reel—Regularity of layers desirable—Finishing winding of wire—How to make the disc—Size and cost of plate—How disc may be best cut out—Mouth-piece or speaking trumpet—Cover of box in original state not suitable—Adverse action of cover of box on disc—How to treat cover—Elastic band round ledge—How to dispose of ends of wire—Must be passed through case—Difficulty in boring holes for wires—How overcome—Putting parts of telephone together—Screws for ends of wire—Testing the work—Necessary space between top of box and magnet—Two instruments necessary—Connection of pair of telephones—Treatment of insulating coverings—When battery is necessary—Signal bell.

Introduction.

BY the above title my readers will understand that it is not my intention to enter into any deep scientific description of the telephone, as that would be out of place in a work of this character; but, at the same time, feeling sure that no real amateur would wish to make anything without understanding a little of the principle and theory of the work he has in hand, I will in a few words endeavour to explain the action of the

telephone so far as I can, without using technical or obtuse terms, referring those who wish to have a complete theoretical description to any of the numerous text-books upon magnetism and electricity.

Professor Bell's telephone.

The articulating telephone was brought to its present state of perfection in 1876, by Professor Graham Bell, of Boston; and Fig. 2 gives a correct view of his telephone, both as regards size and shape, the magnet alone excepted, which, instead of being a plain round bar of magnetised steel, as I have shown, is, in the Bell Telephone, a sort of compound one.

Close relation of magnetism and electricity.

Thanks chiefly to the immortal Faraday, we now know that magnetism and electricity, if not exactly one and the same thing, are very closely related to each other; for by electricity we can produce magnetism, and by magnetism we can obtain electricity, the telephone coming under this latter head.

Influence of magnets on surrounding atmosphere.

Action of voice on disc of telephone.

All magnets affect the atmosphere around them, creating a kind of magnetic influence or power, which is easily seen by their effect on needles or small bits of iron placed near them, it not being at all necessary for the magnet to *touch* the needle to exhibit this force; and, inversely, a piece of iron brought near a magnet will affect it, or alter its magnetic power. Now the voice, thrown on to the small iron disc, causes, by the waves of sound, this disc to vibrate; and as it vibrates, it goes nearer and farther from the end of the magnet, thereby altering the magnetic power or atmosphere surrounding it. This alteration of power causes minute currents of electricity to flow through the coil of fine wire around the magnet, the currents varying in exact proportion to the vibrations of the disc; and as they flow along the wire to the telephone at the other end, they in the same manner alter the power of the magnet there. This magnet, becoming thus made stronger or weaker, attracts and repels the iron disc near it, or, in other words, sets it vibrating; and these vibrations create small waves of sound, which strike on the ear of the person listening, giving a complete and perfect phonetic copy of the person's voice at the first telephone.

Action of magnet on disc.

From the above description it will be seen that the telephone

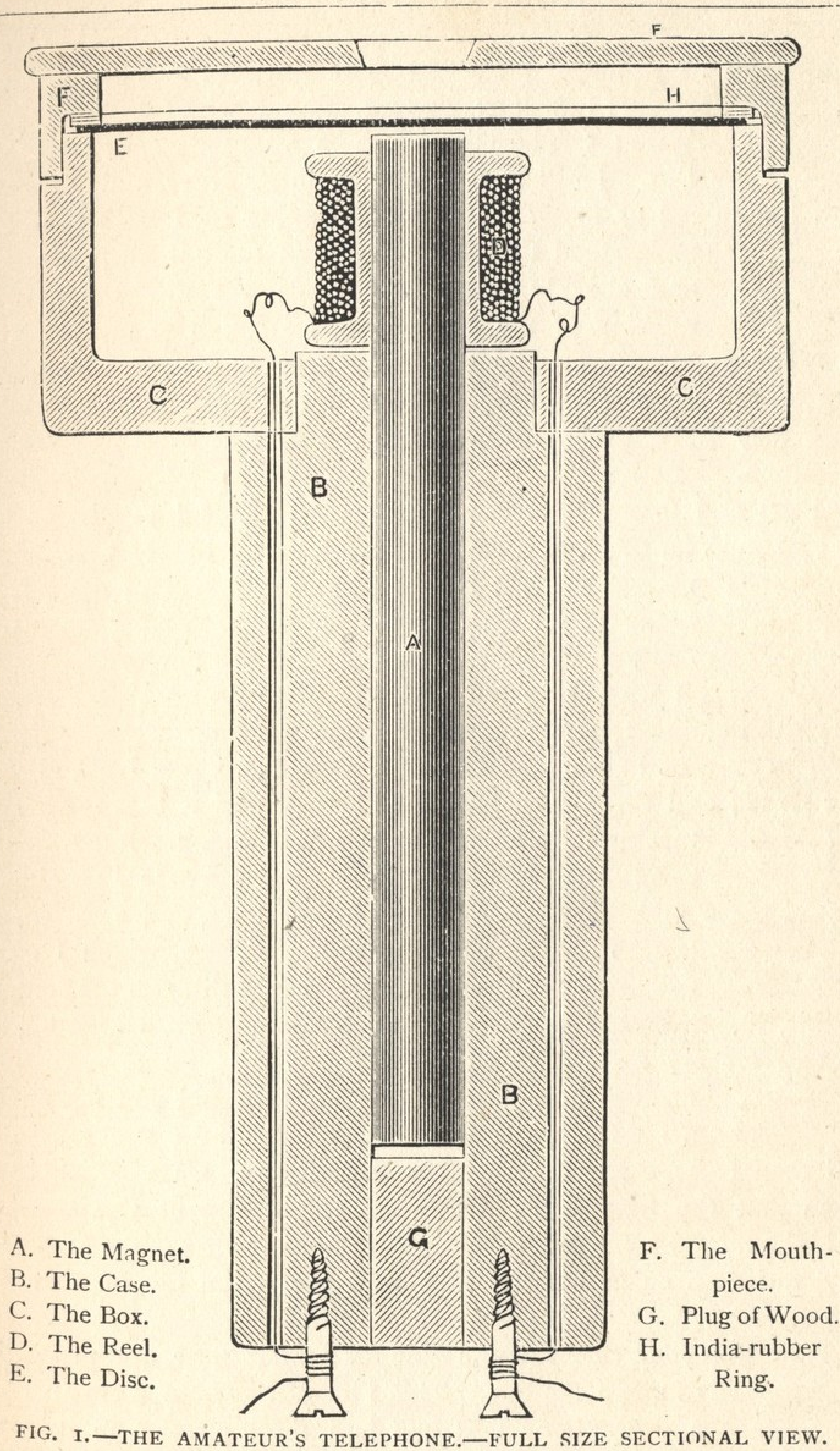


FIG. 1.—THE AMATEUR'S TELEPHONE.—FULL SIZE SECTIONAL VIEW.

consists of six principal parts :—1. The Magnet ; 2. The Case, or Holder ; 3. The Box ; 4. The Reel of Silk-covered Wire ; 5. The Disc ; 6. The Mouthpiece, or Cover of Box. I will now take each in its order, and describe how I obtained or made them; and in doing so, I wish it to be understood that I endeavoured to do it all as simply and cheaply as possible, consistent with the actual working of the instrument, leaving it to my readers to make any improvements they may like ; and those who have lathes will soon find ample scope for their ingenuity when once they have mastered the principle of this most wonderful invention.

Principal parts of telephone.

Course of procedure indicated.

First and foremost comes the magnet. This I purchased at an optician's for 9d., and it consisted of a round bar of well magnetised steel, 4 inches long, and $\frac{3}{8}$ inch in diameter. Some of my readers may prefer making their own ; but as they must purchase the steel, and possess a powerful magnet to magnetise it with, I do not advise them to do so, especially as they can obtain one ready made for so small a sum.

The magnet and its cost.

The case, or holder, can be made with No. 3 (the box), all in one piece ; and those who have a lathe will find it best to do so, turning the whole up as shown in Fig. 2. But I made them separately as follows :—For the case I obtained a good piece of hard wood, about $4\frac{1}{2}$ inches long, and sufficiently thick to plane up to $1\frac{1}{2}$ inches square, which I did, taking off the sharp corners. Right through the centre of this, lengthways, I bored with my brace and bit a hole large enough for my magnet to fit into. As it is better to have the magnet fit tightly into the hole, should you not have a bit the exact size, use one the next size smaller, and then enlarge the hole with a rat-tail file. Care should be taken that the hole is right through the centre of the wood ; and should your bit be rather short, bore from each end halfway, and then clean out the hole with the round file, or a small gouge.

Case or holder.

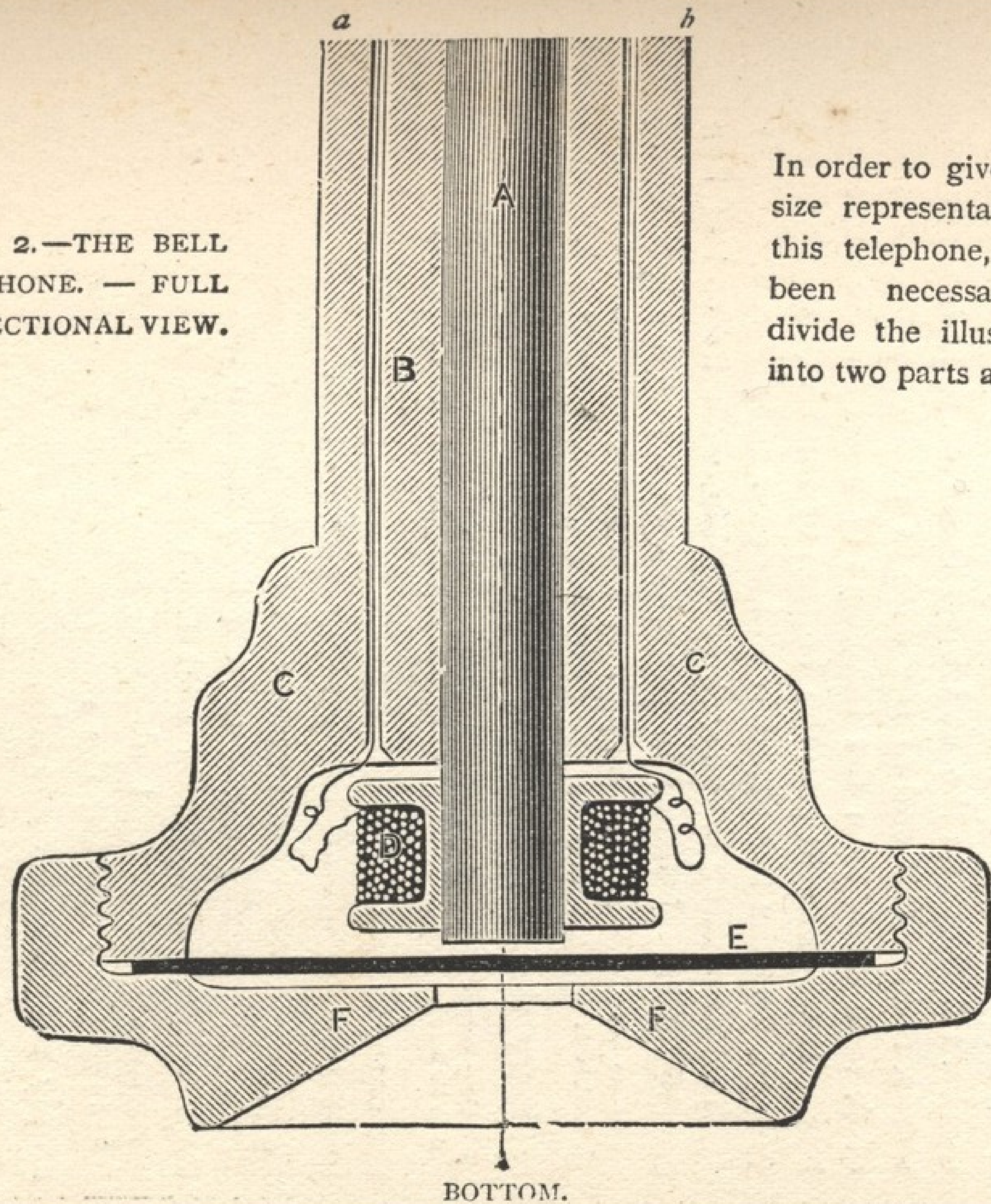
How to make the case.

Fitting in the magnet.

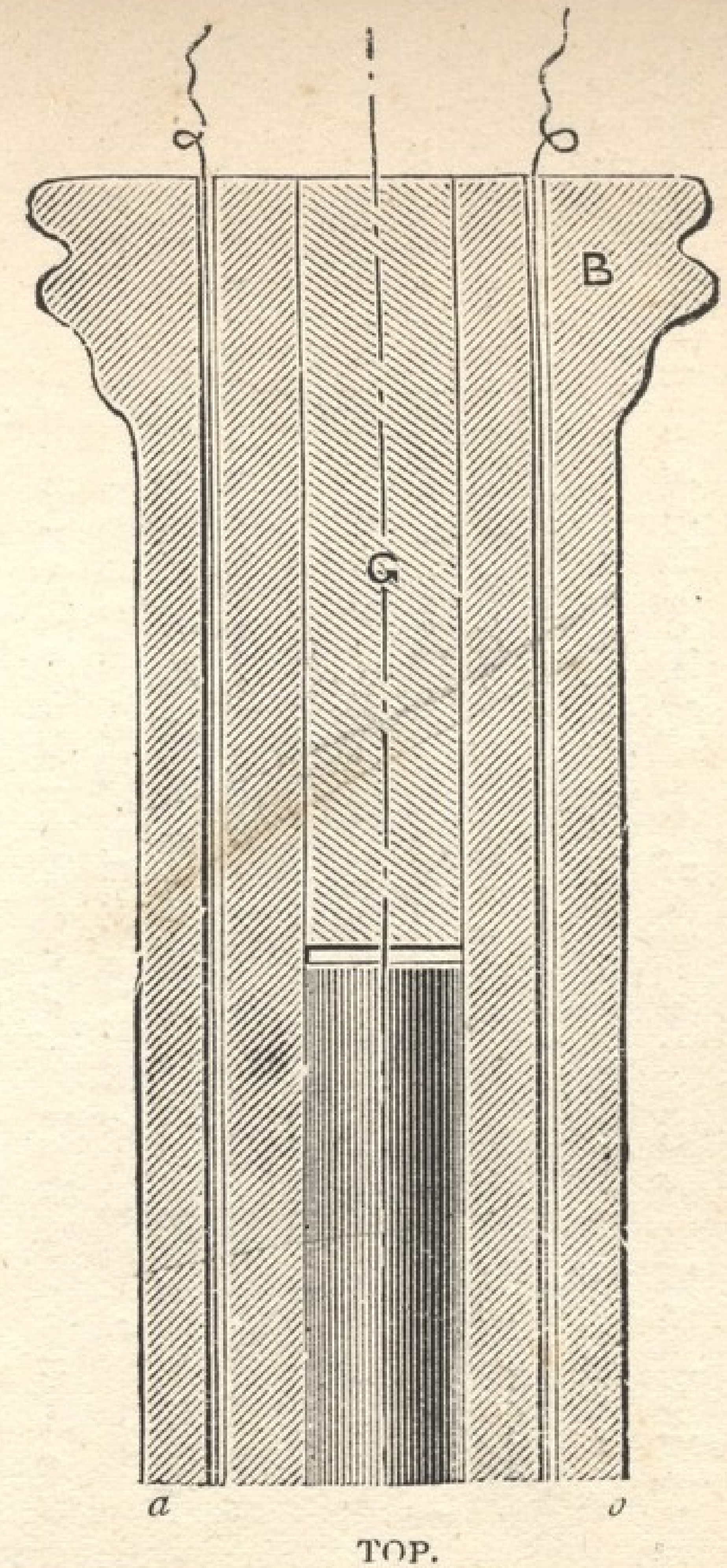
Now put your case on one side for a short time, and proceed to make the box. This I obtained from a chemist's, and was one that had had tooth-powder in it. It was made of turned wood, and measured 3 inches in diameter, and

The box.

FIG. 2.—THE BELL TELEPHONE. — FULL SIZE SECTIONAL VIEW.



In order to give a full size representation of this telephone, it has been necessary to divide the illustration into two parts at *a b*.



1½ inches deep, cover and all, and, being thick and strong, proved just the very article. In the bottom of the box I cut a hole, 1 inch square, and in the cover I cut a large circular hole, leaving only a ledge all round, about ⅛ inch wide. I will afterwards show how I made this cover into the mouthpiece; but before doing so, let us finish the case, which I will now return to. When laid aside, it was a piece of wood, 4½ inches long and 1½ inches square, in section, with a ⅜-inch hole right through its centre from end to end. Measure the thickness of wood in the bottom of the box, where you made the 1-inch square hole, and mark it off from one end of the case by a pencil line on each of the four sides but allowing about $\frac{1}{16}$ inch over. Then on the square end of the case mark around the hole a square of 1 inch. Now with your tenon saw cut through your marks, till those on the end meet those on the sides; or in other words, reduce the end of the case to 1 inch square for a distance of $\frac{1}{16}$ inch more than the thickness of wood in the bottom of the box. It will now fit into the bottom of the box, and project inside $\frac{1}{16}$ inch, and the two together will appear as in Fig. 1.

Suitable box for purpose in view.

Holes in top and bottom.

Completion of case.

Attachment of case and box.

The next thing is the reel, or bobbin, with its coil of fine silk-covered wire. I found in my wife's work-box a small reel, which was the very thing I wanted. It had had red cotton or silk on it, and was about half the length of the ordinary thread-reels, being ¾ inch long over all, and the flanges were ⅞ inch in diameter. The hole through it I enlarged to exactly the same size as the one through the case, so that the magnet fitted tightly into it. Around this reel must now be wound the wire, or coil, as it is called. This wire must be purchased, as few, if any, amateurs could make it, and even if they could it would not be worth their while, as it would cost them more than the ready made article. I obtained some at the same shop where I bought the magnet. About forty or fifty yards is amply sufficient for one telephone, and this costs about 5d. or 6d. It is so exceedingly light that they sell it by weight, at about 1s. per ounce, and I found that one ounce contained about ninety yards. The copper wire is No. 36, Birmingham Wire Gauge. To wind it around the reel, first of all

Reel, or bobbin.

Fitting magnet to reel.

The wire.

Quantity required.

Its cost and gauge.

bore a small hole with a bradawl through one flange of the reel, as close to the body as you can, and pass the end of the wire through it from the inside. Leave about six or seven inches through, and then wind the rest around as neatly as you can.

Attachment of wire to reel.

So long as you wind in one direction only, it does not matter about the layers not being quite even, but it looks better to keep them straight, and you will be able to wind more around than if you place them anyhow. Be careful not to handle the wire roughly, nor to fray the silk, as it would prove fatal to success if the wire became exposed in two or three places, so as to allow these parts to form contact, or copper to touch copper, as then the electric current would take a short road through this contact instead of going round and round the reel by the whole coil. When you have wound round as much as the reel will take—that is level with its flanges—finish off at the same end or flange as you began, leaving about six or seven inches over, and the coil is complete.

Regularity of layers desirable.

Finishing winding of wire.

The disc is usually made of a peculiar sort of iron called "ferrotype," plates of which are used in special form of photograph known as a ferrotype. It can be purchased at any shop selling photographic chemicals and apparatus, generally a druggist's. A plate 4¼ inches by 3¼ inches is large enough for your purpose, and costs about 2d. Should, however, any of my readers find a difficulty in obtaining this special kind of iron plate, they will find a sheet of thin tin answer quite as well.

How to make the disc.

Size and cost of plate.

Measure the inside diameter of the box, and mark on a piece of ordinary writing paper with a pair of compasses a circle about ⅛ inch larger. Cut this out neatly with a pair of scissors and gum it on to the iron or tin plate, and then with the same scissors, if they are strong enough, cut the plate out round the paper. Some may exclaim, "Why not mark out the circle on the plate direct?" To this I answer, that it is best to avoid scratching or indenting the disc in any way, especially the central part; and, moreover, the paper keeps the disc clean whilst you round off and smooth up the edge with a fine file.

How disc may be best cut out.

I now come to the cover of the box, which forms the "mouth-

piece," or as it is sometimes called, the "speaking trumpet." This cover, when placed on the box, should tightly jam the edge of the disc all round ; and at the same time the inside bottom of the cover should be about $\frac{1}{8}$ inch clear of the centre part of disc to allow the latter to vibrate. A glance at the drawing will show what I mean. The cover of my tooth-powder box, however, bothered me a little, for I found that the centre of it was thicker than the edge, and so the inside as well as the outside was convex, just the opposite to what I required (see Fig. 3). I did not observe this at first, and so I thought that all I should have to do would be to cut a circular hole about $\frac{3}{8}$ or $\frac{1}{2}$ inch in diameter in the centre, through which the voice would reach the centre of the disc. When, however, I had got my hole cut, and the cover put on over the disc, instead of touching the edge of the latter all round, it was pressing on the centre, and the

Mouth-piece or speaking trumpets.

Cover of box in original state not suitable.

Adverse action of cover of box on disc.

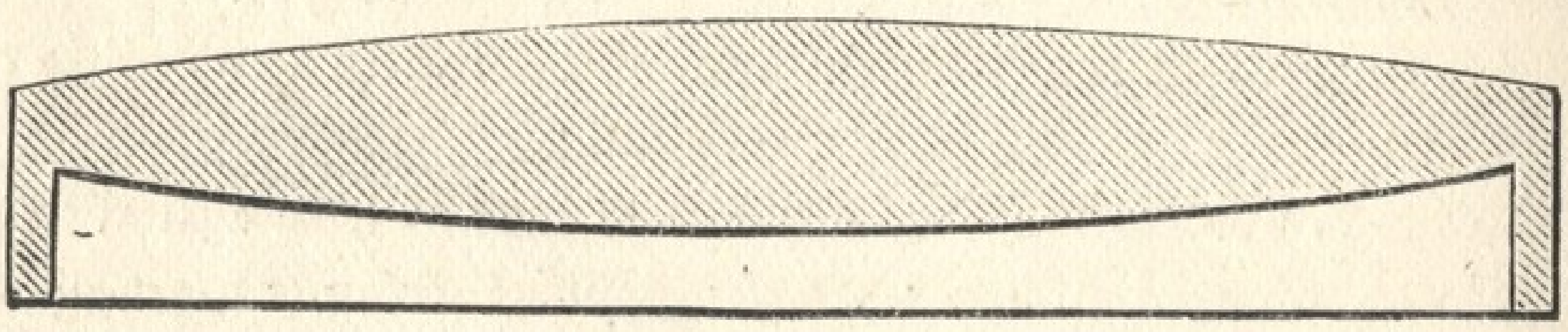


FIG. 3.—SECTION OF TOP OF WOODEN BOX, BEFORE ADAPTATION.

edge of the disc was left free—the very reverse to that which I desired. To remedy matters I tried to put a liner inside all round the edge, but this kept the cover off from the box too much to fasten them together. I then thought it best to cut out all the bottom of the cover, leaving only a ledge all round about $\frac{1}{8}$ inch, and on to this glue *outside* a new bottom, in which the small hole for speaking through could be cut. I found this a complete success, and the cover, when finished, was as shown in Fig. 1.

How to treat cover.

To make sure of the ledge of cover touching well all round the ledge of disc, I put between them a small elastic band, to form a joint. An ordinary elastic band or ring will do ; and if one cannot be obtained exactly the size, get one a little larger in diameter, and cut it round its outside edge neatly with a pair of scissors, until it fits into the cover, and lies flat without crease or wrinkle.

Elastic band round ledge.

The various parts of the telephone are now nearly complete, one thing only remaining to be done before fitting all together—the two ends of the wire which were left on the reel must be disposed of. One end has to be connected to the line leading to the distant telephone, and the other end has to go "to earth," as the technical expression is; that is, must be connected to the nearest gas-pipe, or, better still, water-pipe, through which the electricity speedily finds its way into the earth. But the wire around the reel is so fine and delicate, that if the ends were led out direct through a hole in the side of the box, they would become broken in a very short time, and, moreover, would be in the way when handling the telephone. They are, therefore, usually led up through the case, passing through two small holes bored one on each side of the large hole in which is the magnet, and then fastened to a pair of terminals, by which they can be connected to thicker and stronger wires. Should any difficulty occur in boring these two small holes lengthways through the case, so as to keep them parallel, and not let them run into the magnet-hole on the one side, or out through the side of the case on the other—a likely thing to occur if your gimlet is not long enough—I would recommend the plan I myself adopted, which was, instead of boring the two holes, to make with my tenon saw two fine slits the whole length of the case, one on each side, sawing into the wood about $\frac{1}{4}$ inch. Into these slits the wires were laid, and then filled in with a little wax. I need scarcely say that boring the holes is by far the neater way, and I only mention the slits because it shows how even a slight difficulty can be overcome.

How to dispose of ends of wire.

Must be passed through case.

Difficulty in boring holes for wires.

How overcome.

Now let us put all our parts together. First of all take the bobbin, with its coil of wire, and push one end of the magnet right through until it projects beyond about $\frac{1}{16}$ inch. Then leaving it there, push the other end of the magnet up into the hole in the case until the bobbin touches the reduced square end. Now pass your two ends of wire up through the small holes—or lay them in your saw slits—leaving the ends projecting about one inch, and fasten them there by screwing two small brass wood screws into the end of the case, close to the holes—around which you twist

Putting parts of telephone together.

Screws for ends of wire.

your ends—first of all laying the copper wires bare by scraping off the silk covering with your penknife. Now put the box on to the case, over the reduced square end, and if you have made a good fit it is better not to glue or fix it permanently until you have finally tested the instrument. You will observe that it is requisite to have the outside diameter of bobbin a little smaller than the square hole in box, so that the latter can pass over it. Now place a straight-edge across the top of box, and see what clearance you have between it and the end of the magnet. A little less than $\frac{1}{16}$ inch is the proper space, and if you find you have more, you must file down the edge of the box, or rub it down on a sheet of glass-paper. Now lay the disc on the edge of the box, and over it the india-rubber ring, and then, finally, put on the cover or mouthpiece, and your telephone is complete, and should appear as in Fig. 1.

Testing the work.

Necessary space between top of box and magnet.

But for the same reason that it is of no use speaking to a man without ears, or listening to a dumb man, so one telephone by itself is of no practical value, and to hold telephonic communication it is therefore necessary to have two instruments. You must, therefore, now set to work and make a second telephone precisely as I have described the first. Assuming this done, and you have your two telephones complete, all that is necessary for speaking and hearing through them is to connect them together by wires—one wire leading from one terminal on the one instrument to a terminal on the other—and a second wire attached to each of the other terminals and leading to respective gas or water pipes. The length of the wire between the telephones can be very long, but it must be insulated—that is, covered with something, generally cotton or gutta-percha—the latter substance being used for outdoor purposes. This wire can be purchased for about 1d. per yard. Be careful, when attaching the ends to your telephones or water pipes, to first of all scrape off the insulating covering. A few twists around the brass screw will suffice, and also around the water or gas pipe; but before doing this to the latter, see that the pipe is clean, and not covered with paint or anything liable to stop the electric current.

Two instruments necessary.

Connection of pair of telephones.

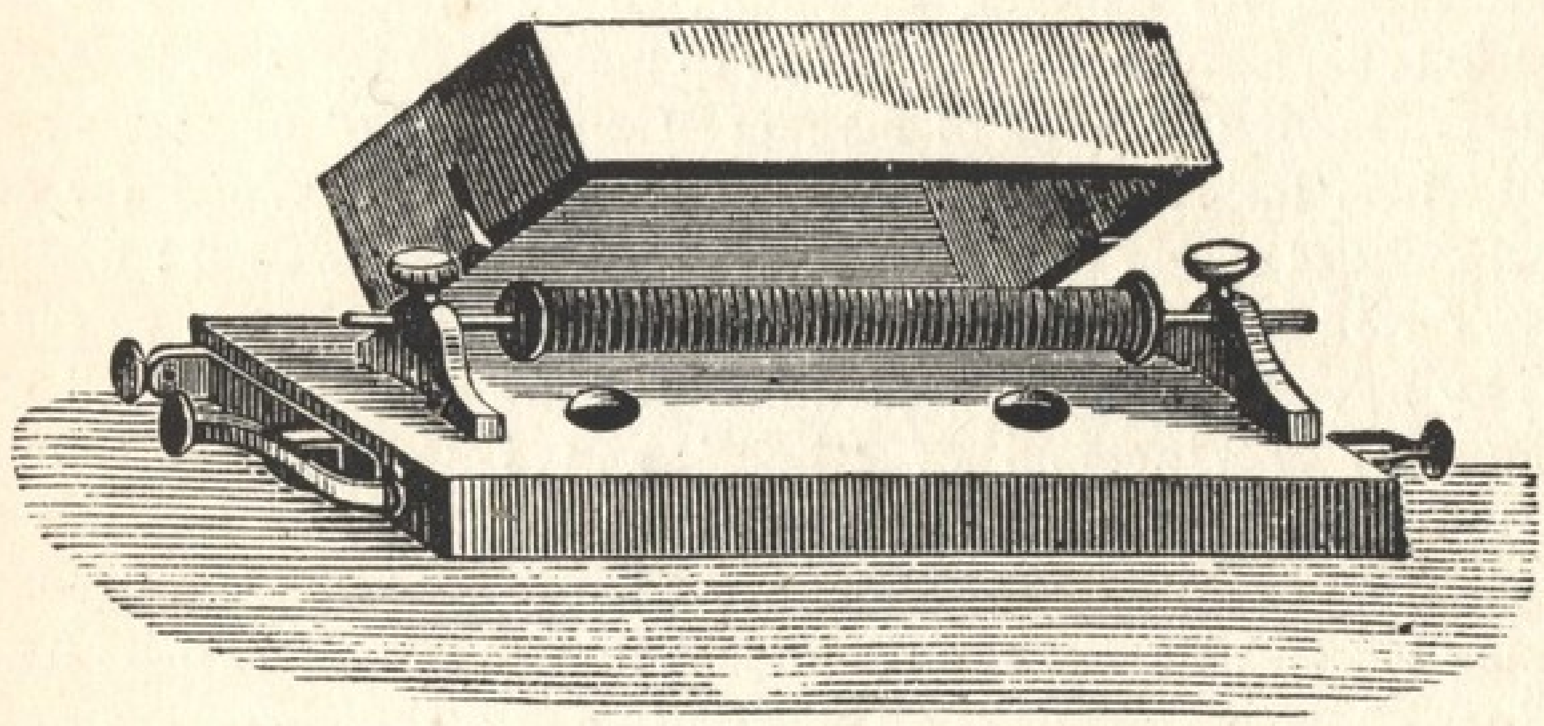
Treatment of insulating covering.

My readers will perceive that I have made no mention of

batteries. My reason for this is that no battery is required for the telephone unless the distance is great, the magnet itself giving a sufficient current; but as one must have a bell or some signal to call attention before speaking, then batteries are used, and one cell is usually attached to the telephone. How I fixed up my bells and made my switches to work them with my telephones—in short, how I put up telephonic communication in my house—must be left for another chapter.

When battery is necessary.

Signal bell.



APPARATUS OF TRANSMISSION.

CHAPTER II.

GETTING INTO WORKING ORDER.

Signal to call attention—Why necessary—Electric bells preferable to pneumatic bells—Battery necessary—Leclanché battery—Old form of battery—"Silvertown Patent Leclanché Battery"—Agglomerate blocks—Sizes of batteries—Charge for porous pot—Painting brass clamp—Cost of cells complete—Improved agglomerate cells--Box for cells—Connection of cells to form battery—Keeping batteries in order—Connection of batteries and bells—Course of "line" wire—Staples to secure wire—Mode of opening communication—Disposition of telephones at close—Switches—How to make them—Spring for switch—Fixing the switches—Attachment of spring—Hanging up telephone—Fixing "bell and battery" switch—Arrangements for eyes and screws—Channels for wires—Attachment of wires—Filling in channels—Cost of wire—Ring for hanging telephone—Switch-board: how to be made—Electric bell—Electro-magnet—How to make electro-magnet—Ampère's rule for determination of poles of magnet—Completion of magnet—Material for board—Iron for armature—Platinum on armature—Wood for armature—Attachment of spring to wood—Round-headed screw—Bell: whence obtainable—Terminals—How to ring bell—Influence of electric current—Substitutes for bell—Difficulty in adjustment of screw—Position of bell—Setting in working order—Junction of "line" and battery wires—Connection to "earth"—Mode of joining up wires—Communication between stations—Summons given—Reply to summons—Change of currents—Reconnection of warning bells—Utility of two telephones to each station—Position of "listening" telephone—Thompson on electricity and magnetism.

I MENTIONED in the preceding chapter that, theoretically, it is unnecessary to have a battery to enable one to speak through the telephone; but for reasons which I will now explain, I do not think much practical use can be made without its aid. For, assuming that you have successfully made your two telephones, and have fixed up one in your workshop or "den," on the ground floor, and the other in a room on the top story of the house, with the wires connecting the two to each other, and to "earth," it is evident that before you can speak from your "den" to anyone upstairs

you must be able to call his attention, as it would be absurd to expect that person to be constantly standing with the telephone at his ear, on the mere chance that you might wish to speak to him ; and if you have to give him notice beforehand, or send a servant up to him to tell him to go to the telephone, it then becomes a toy of no practical value or use. Means must therefore be employed to call attention, the simplest being some sort of bell. If your workshop be near the kitchen, then the ordinary house-bell rung, say three times, might give you notice, but all ordinary house-bells are only intended to ring one way, and so you could not answer nor ring up in turn.

Signal to call attention.

Why necessary.

Pneumatic bells would do, but they involve the trouble and expense of fixing a small pipe to run the whole distance between them ; I should therefore strongly recommend your adopting electric bells, the more so because the same wire which connects the telephones can be made the medium of ringing the bells ; and apart from this, which by itself is a great advantage, I feel sure that those who have made their telephones are desirous of continuing their experiments in elec tricity, and of employing the same subtle agent to work them.

Electric bells preferable to pneumatic bells.

But electric bells require batteries, for although the electric current created by the magnets in the telephones is strong enough to transmit the minute wave sounds to the sensitive human ear, it has been calculated that it is about a thousand million times less than the current used in ordinary telegraphic work, and therefore, I need scarcely add, quite powerless to set a bell in motion.

Battery necessary.

Of the various kinds of batteries, the one most suitable for our purpose is called after its inventor, the Leclanché, two forms of which are now in use ; the old form in which a porous pot is employed, and the new and improved form in which Mons. Leclanché has substituted movable plates for porous pots. It will be unnecessary to do more here than give a brief and general description of both forms.*

Leclanché battery.

* For a more minute and detailed description of the Leclanché battery, the reader is referred to "Electro-Plating at Home," by George Edwinson, in the sixth volume of this series.

In the old form of the Leclanché battery one element consists of a porous pot into which the carbon plate is placed and then filled in all round with a mixture of coarsely powdered peroxide of manganese and carbon, the top of the pot being sealed over with pitch or wax, excepting only a small hole to connect to the atmosphere, and allow the gases to escape. This pot with its contents is then placed in a glass or stone jar containing a weak solution of sal-ammoniac and water, into which the other element, consisting of a rod of amalgamated zinc, is also immersed. In the new and improved form, called, I think, the "Silvertown Patent Leclanché Battery," instead of having a coarse powder of peroxide of manganese and carbon, these ingredients are compressed under a pressure of several tons into solid blocks requiring no porous pot to hold them together.

Old form battery.

"Silvertown Patent Leclanché Battery."

Two of these agglomerate blocks are fastened by india-rubber bands, one on each side of the carbon plate, and then all three are put into the jar containing the solution of sal-ammoniac into which is also put the zinc rod.

Agglomerate blocks.

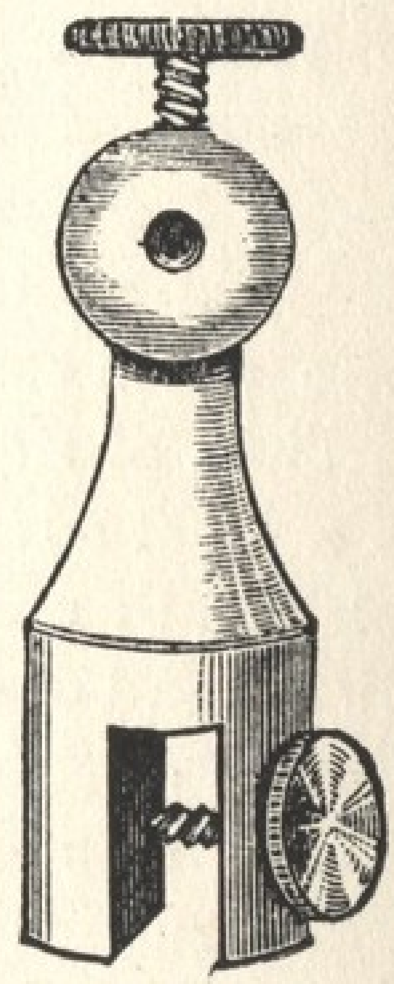


FIG. 4.—BRASS BINDING SCREW. Full size.

Both forms are usually classed under three sizes: No. 1, large; No. 2, medium; and No. 3, small. I should advise your adopting the small size, three cells of which will be ample for each of your two batteries. If you make them in the old form, your glass or stone jar should be about 5 inches deep, and 3½ or 4 inches square or round; the porous pot should be 2 inches in diameter and 5 inches deep, and may be purchased for a few pence; the carbon plate should be about 5 inches long, 1⅛ inches wide, and ¼ inch thick, and will cost about 9d.; it must be fixed at one end into a clamp or brass binding screw, as shown in Fig. 4, which costs about 6d. The amalgamated zinc rod should be about 6 inches long and ½ inch diameter, and can be purchased with wire attached, complete for 4d.

Sizes of batteries.

Place the carbon plate into the centre of the porous pot, and then fill in all around it to about ¼ inch from the top with coarsely

powdered peroxide of manganese and carbon well mixed together. The carbon plate need not touch the bottom of the pot. Now stick into the powder a short piece of glass tubing about $\frac{1}{8}$ inch diameter inside, and then pour around it and the carbon plate some melted pitch or wax; the glass tube is generally made funnel-shaped, with the wide mouth placed downwards touching the powder to allow the gases to escape freely. The brass clamp on the carbon plate should be also painted with pitch or shellac varnish, excepting only the screw, around which the connecting wire is attached. Now

Charge for porous pot.

Painting brass clamp.

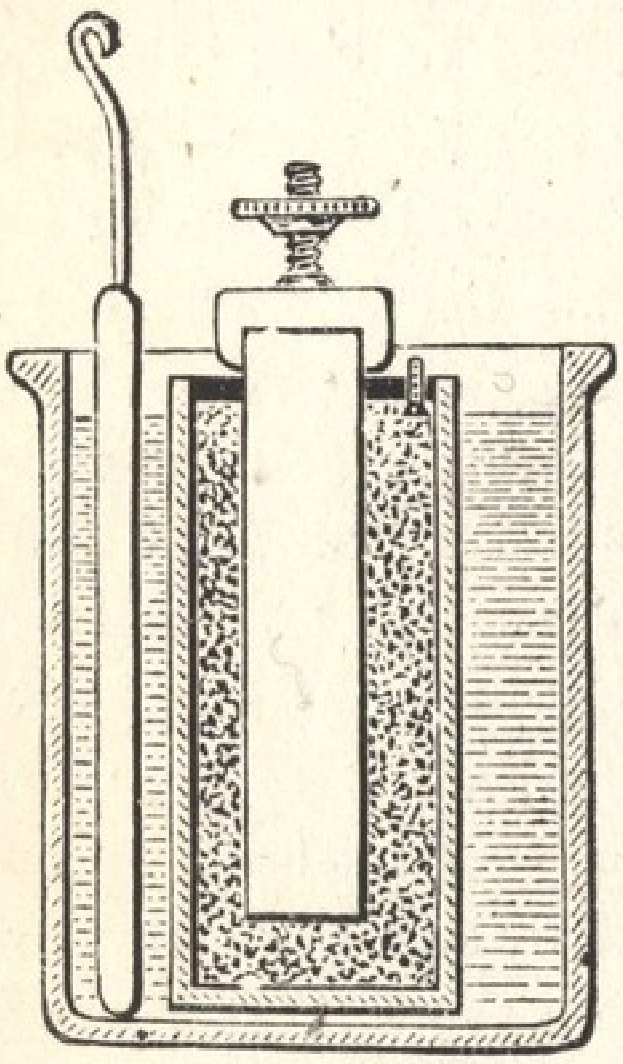


FIG. 5.—LECLANCHE CELL.
Old form, with porous pot. One-fourth full size.

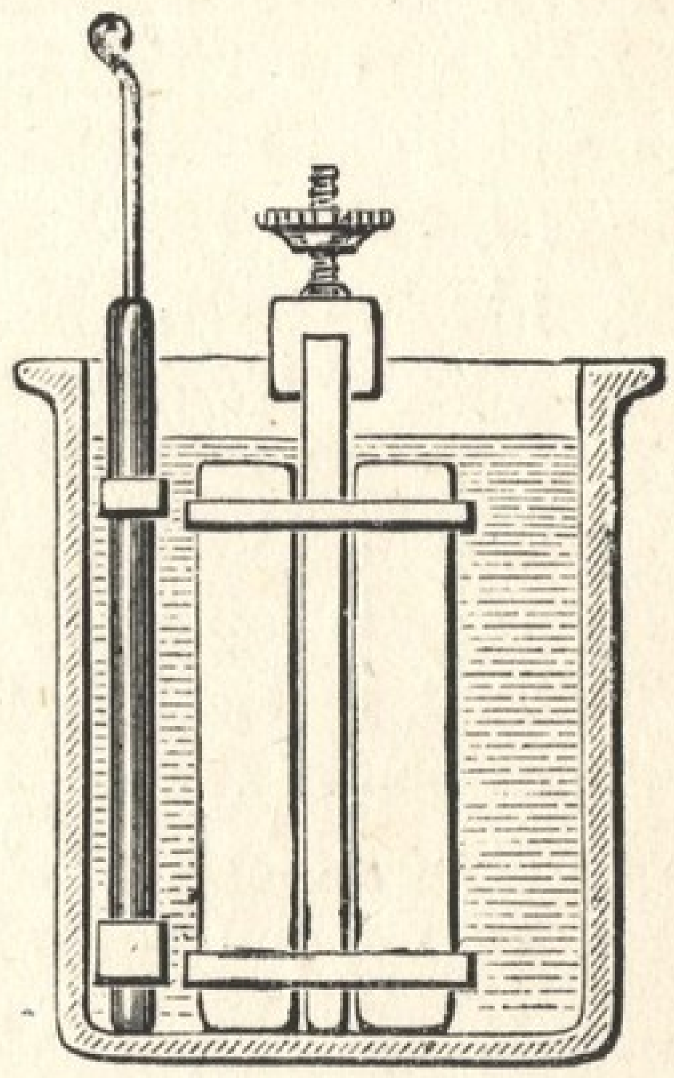


FIG. 6.—LECLANCHE CELL.
New form, with agglomerate blocks. One-fourth full size.

put the porous pot with its contents complete into the glass or stone jar together with the zinc rod, and fill up about seven-eighths full with clean water in which has been dissolved sal-ammoniac in the proportion of 2 oz. to a pint of water, and your cell is complete, as shown in Fig. 5.

Those who do not care to take the trouble of filling and completing the porous cells, can purchase them ready filled, with carbon, etc., for 2s. 6d. each, small size. The usual price for a cell complete and ready for work, with outer square glass jar, is 3s. 6d., small size.

Cost of cells complete.

For the improved agglomerate cells, the carbon plate is as

above described, with brass binding screw complete, and the two blocks must be purchased, as you could not possibly make them. They are sold in pairs, and a pair of No. 3 size will cost between one and two shillings. When joined to the carbon plate, and placed in the glass jar, the whole cell is as shown in Fig. 6. The zinc rod must be kept clear of the blocks by india-rubber rings, for should it accidentally touch them, it causes what is termed, "local action," which is a technical term, meaning that injurious chemical action would continually take place, wasting away the zinc the same as if the battery were working. To keep the cells together and preserve them from breaking, they should be kept in a wooden box, which can be easily knocked up by any amateur. For three cells of the sizes I have given, the box should be about 12 inches long, 5 inches wide, and 8 inches deep, all inside measurements, and made of ½ inch wood.

Improved agglomerate cells.

Box for cells.

The battery is formed by connecting up the cells as follows: the carbon of the first cell is left free and the zinc rod is joined by its wire to the carbon terminal of the second cell, the zinc of which is in the same way joined to the carbon of the third cell, the zinc of which is left free.

Connection of cells to form battery.

I will now add a few hints for keeping your batteries in order: —1st. Do not put them in a warm place or too near the fire, as the water in the outer jars soon evaporates, when more must be added. 2nd. To prevent the crystals from rising up over the glass jar, rub the inside of the neck with a little tallow. 3rd. Scrape off with a knife the crystals which after a time form on the zinc rods, as they stop the effectual working. 4th. See that your wires and terminals are kept clean, and your conducting wires properly insulated. 5th. Every six months or so examine your battery and wash out the cells thoroughly, putting in fresh sal-ammoniac, and if requisite new zinc rods.

Keeping batteries in order.

So much for batteries, now let us see how to connect them to the telephone and bells.

The first thing to decide upon is where you intend placing your two telephonic stations, and then the most direct way to run the wire between them. I placed mine in the recess behind the window shutter, there being ample space there for the telephone with its switches, bell, and connecting

Connection of batteries and bells.

wires ; and by boring with a good-sized gimlet a hole diagonally downwards through the lower sill of the window, clear of the sash, I led the wire to the outside of the house and straight up to the window on the top story. The battery I placed on the top of the window framing behind the curtain pole, where it was out of the way and yet close at hand.

It is difficult to give definite directions as to running the wire between the two stations—technically termed the "line" wire—but always choose the most direct and shortest way possible ; and if you should wish it to go from the lower to the upper part of the house, you will find it best to take it straight up *outside*, in and out of the window-sills. If, however, the two rooms are not so situated, then you must lead it along the passages and round the walls of the rooms, keeping close to the ceiling moulding, and fastening the wire at intervals with small holdfasts, or U-shaped pointed wire, commonly used for fastening up bell-wire. The wire must be covered with gutta-percha for exposed places, but inside the cotton-covered is less conspicuous and neater.

Course of "line" wire.

Staples to secure wire.

Now let us see what is to be done, supposing No. 1 station wishes to communicate with No. 2 station, and then we shall be able easier to see how to do it. No. 1 must first of all ring up the bell of No. 2 to call attention, this he does by sending a current from his battery along the "line" wire to No. 2's bell. Then he takes off this current, and replacing the "line" in connection with his own bell, No. 2 answers in the same way. Both then take telephones in hand, at the same time connecting them on to the "line" wire in place of the batteries and bells. When the conversation has ended they hang up their telephones, and replace their batteries and bells in connection with the "line" wire so as to be ready when either again wishes to call attention by ringing. These several changes on the one wire are done by means of levers or "switches," as they are called ; the idea corresponding to those used on railways for changing the direction of the rails.

Mode of opening communication.

Disposition of telephones at close.

I will now therefore describe how I made mine, of which there must, of course, be a set for each station. I purchased a few feet of No. 10, B. W. G. brass wire, which is about $\frac{1}{8}$ inch in diameter, and taking a piece about 10 inches in

Switches.

length, with my round nose pliers I bent one end into an eye, as shown at A, in Fig. 7. Then leaving a little straight bit I bent it at right angles to the eye, into two arms, as shown at B and C. I then obtained a piece of brass tubing $\frac{3}{16}$ inch outside diameter, the bore of which just allows the wire to fit into it easily, and cutting it to 1 inch in length, I bent around a piece of thin sheet brass, $\frac{5}{8}$ inch wide and $1\frac{5}{8}$ inch long, as shown in Fig. 8, and before soldering the two firmly together punched a hole on each side for wood screws. I then pushed the long end of the wire cross, Fig. 7, through the tube, and making sure that it would slide up and down easily, finished it off by bending the end into a hook D in the same plane as the eye, and so at right angles to the two arms. When complete, the length over A D is about 4 inches, and the width over the two arms B, C about $1\frac{3}{4}$ inches. To the eye A, I fastened a small spiral spring of brass wire—a piece of clock spring will do, or even an india-rubber band, only the latter will not of course last long—and then the whole forms the "telephone" switch. About 6 inches of the same sized wire, bent into the shape shown in Fig. 10, will do for the "bell and battery" switch.

How to make them.

Spring for switch.

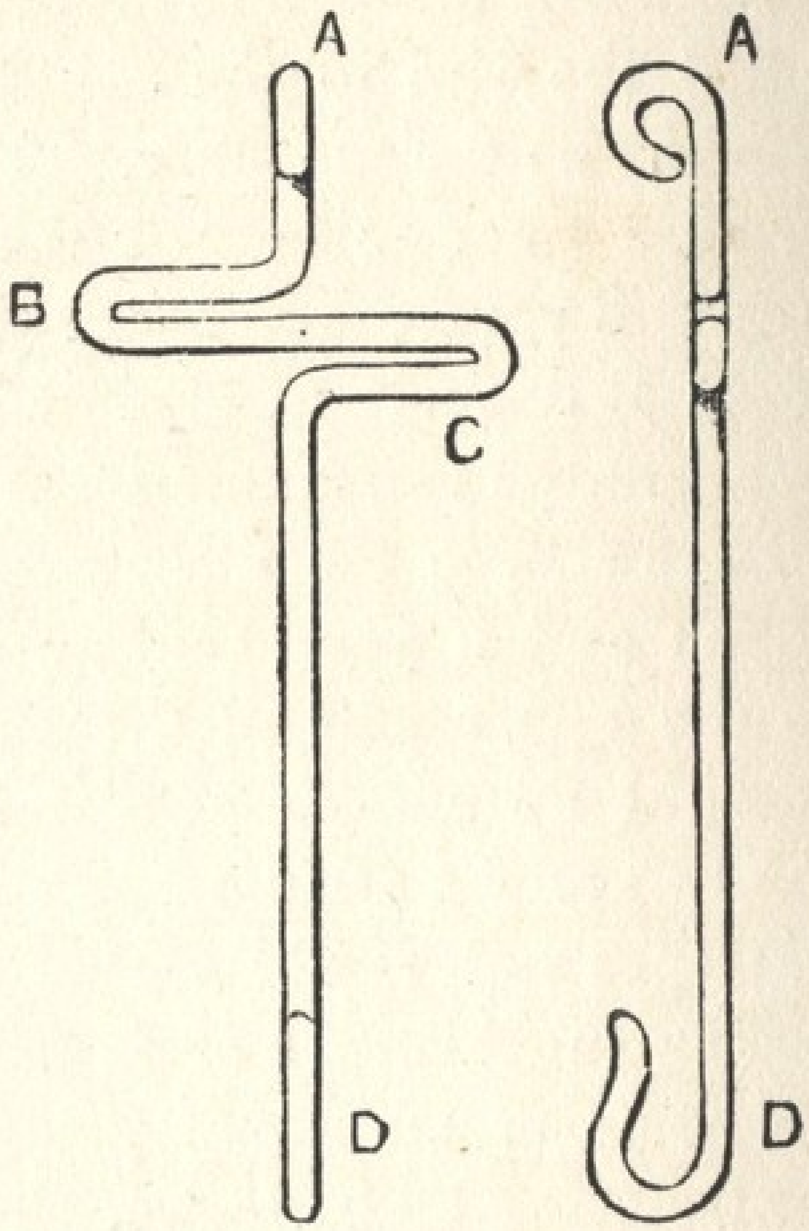


FIG. 7.—BRASS WIRE FOR LEVER OR SWITCH. Half full size.

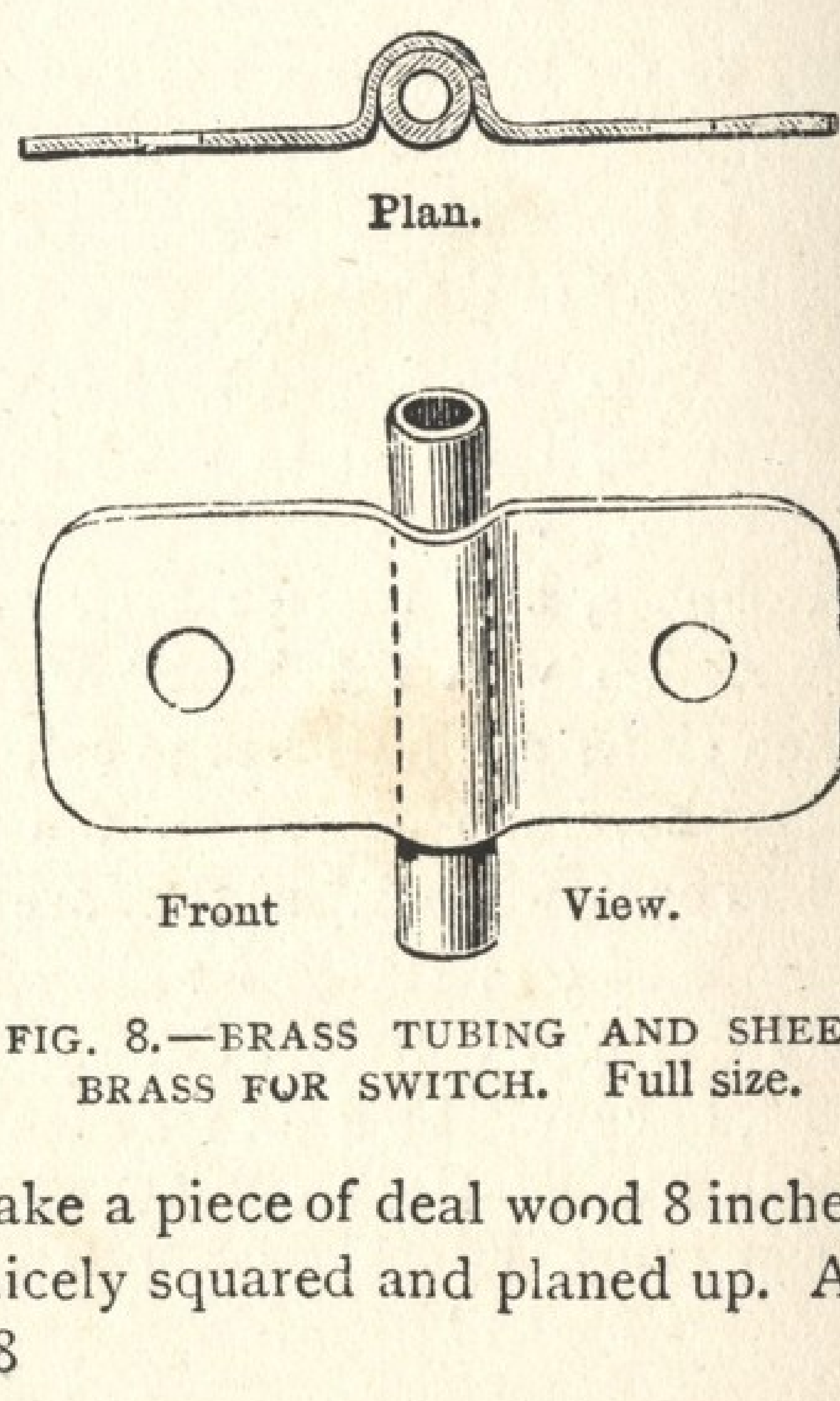


FIG. 8.—BRASS TUBING AND SHEET BRASS FOR SWITCH. Full size.

To fix them in working order, take a piece of deal wood 8 inches long, 6 inches wide, $\frac{5}{8}$ inch thick, nicely squared and planed up. At

a distance of 2 inches from the left-hand side, and parallel to it, make a pencil line down the whole length, upon which you place the "telephone" switch, fastening it there by two brass wood screws through the brass guide. Now, under the arm C, screw into the wood a mushroom-headed No. 5 brass wood screw, about $\frac{7}{8}$ inch long, leaving $\frac{1}{4}$ inch of the shank out, as shown in Fig. 9; and over the arm B screw a brass eye, Fig. 11, allowing about $\frac{1}{8}$ inch play for the switch, that is to say, allowing room for Fig. 7 to slide up and down about $\frac{1}{8}$ of an inch, the arms alternately touching the screw and eye.

Fixing the switches.

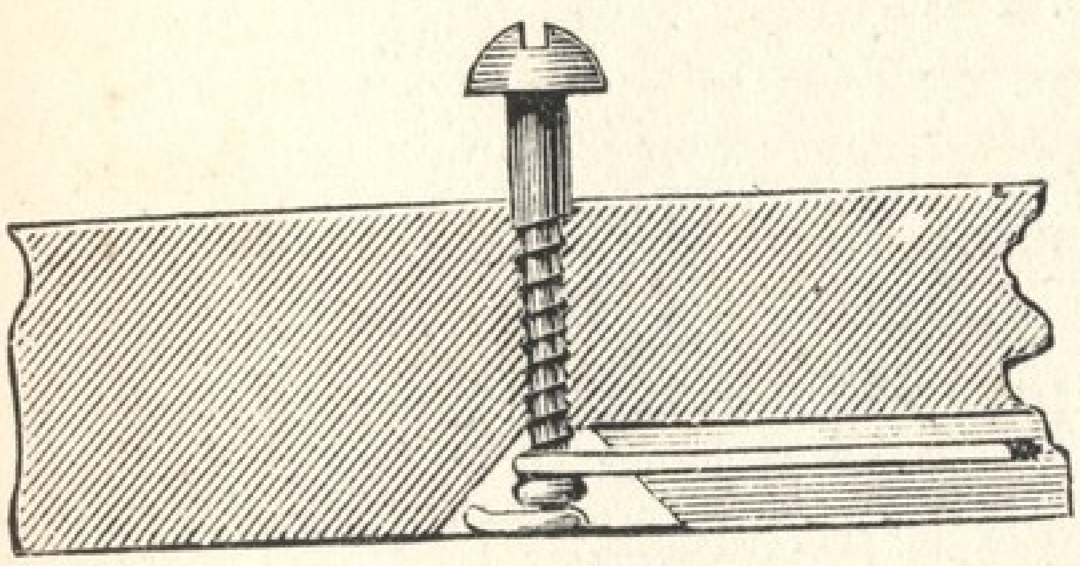


FIG. 9.—DIAGRAM SHOWING HOW TO FIX SWITCH. Full size.

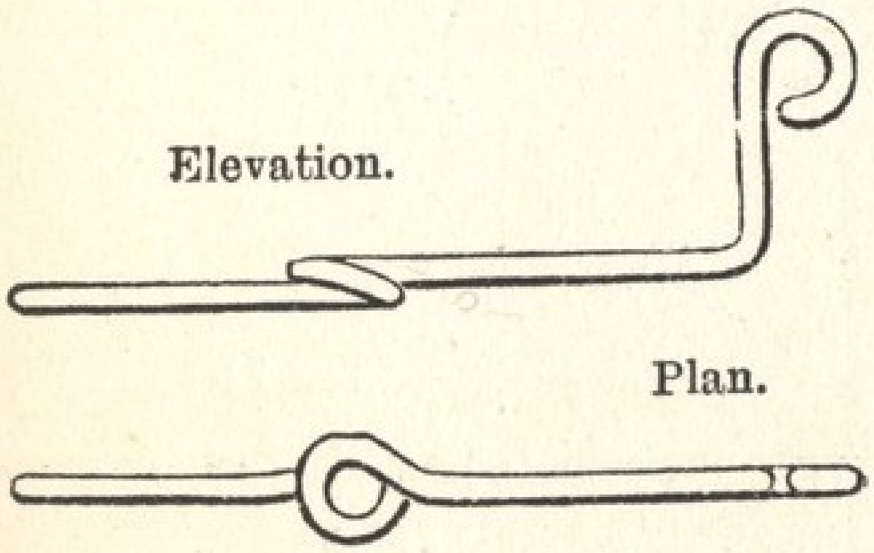


FIG. 10.—WIRE FOR BELL AND BATTERY SWITCH. Half size.

Then fix the little spiral spring to the board by a screw directly above the switch, and at a distance sufficient to keep the arm B touching the screw eye.

Attachment of spring.

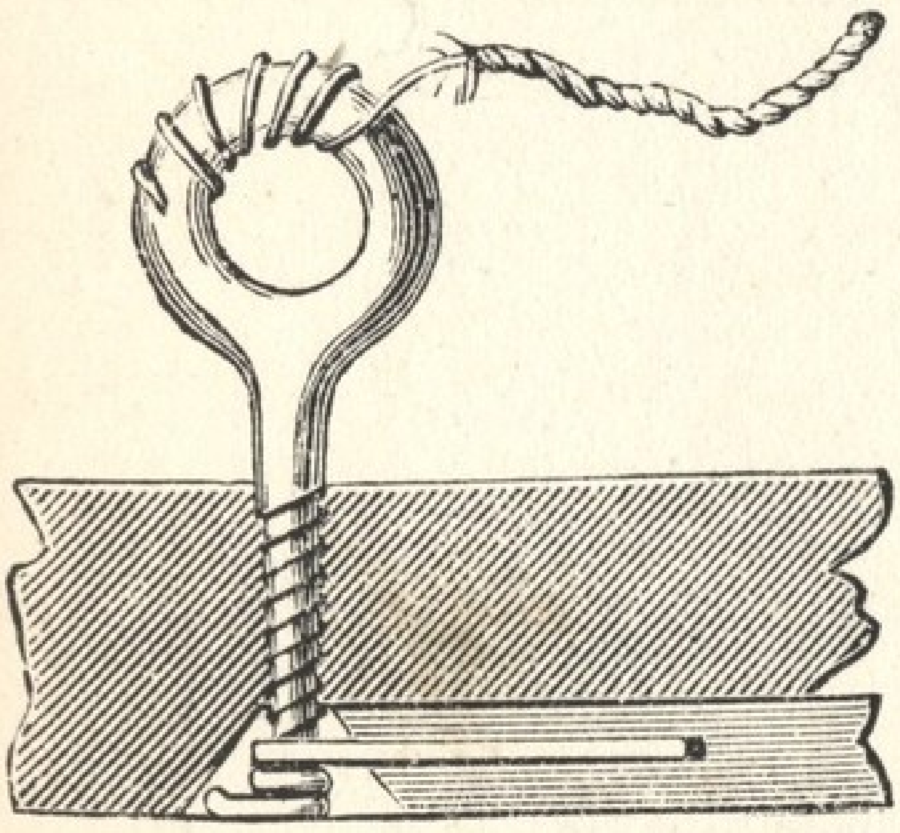


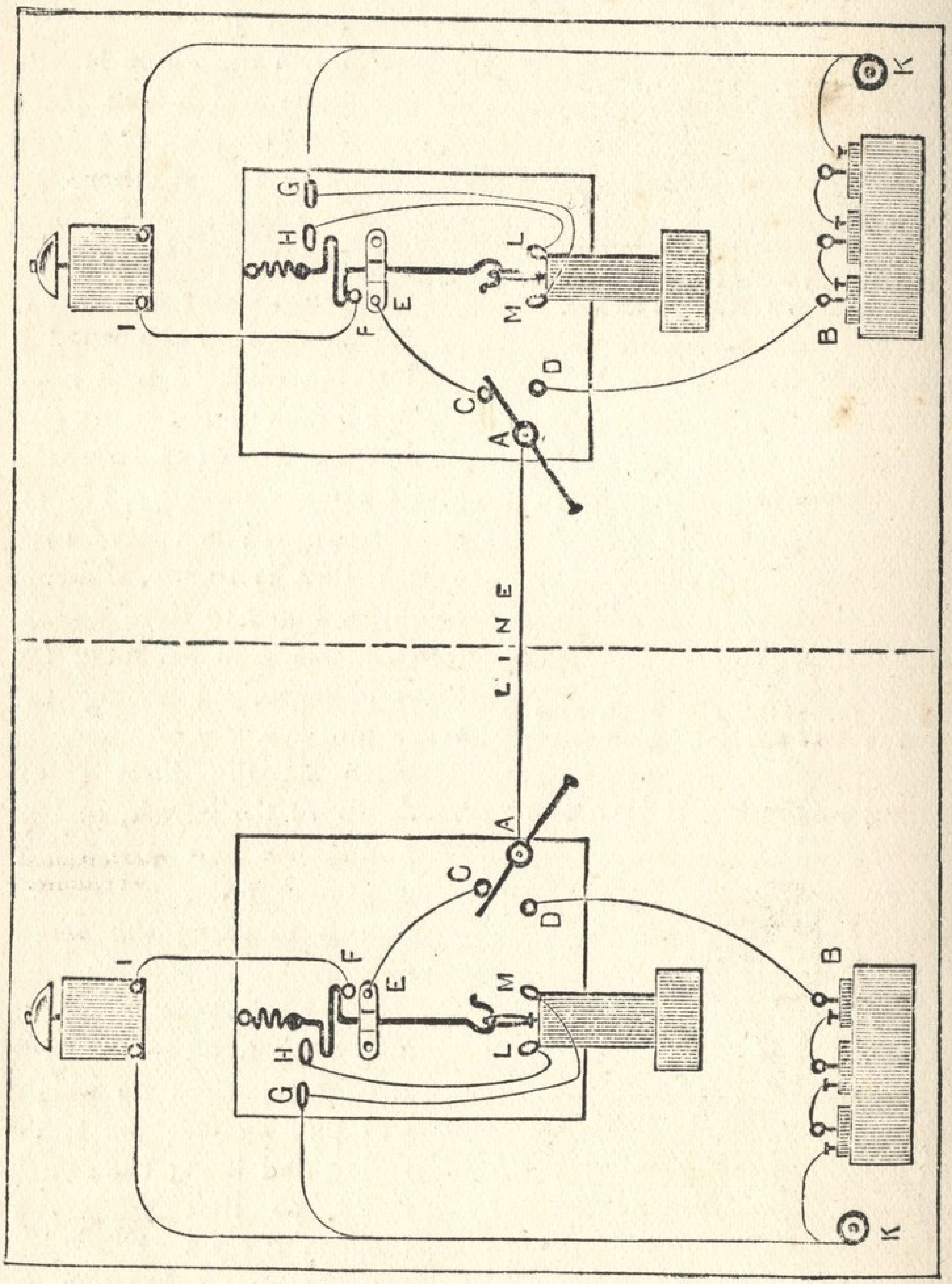
FIG. 11.—BRASS EYE FORMING PART OF FITTING FOR SWITCH. Full size.

Now take your telephone and hang it on to the hook D (Fig. 7), when its weight will pull against the spiral spring and bring the switch down, so that the arm C rests on the screw beneath it. You may find the spring too strong, or what amounts to the same thing, the telephone not heavy enough for this; you must then weaken the spring a little by stretching, or else by

Hanging up telephone.

bringing the screw which fastens it to the board a little nearer the

NO. 2 STATION.



NO. 1 STATION.

FIG. 16.—DIAGRAM SHOWING TELEPHONE STATIONS AND CONNECTING LINES.

switch. This arrangement can be better seen by referring to No. 1 station, Fig. 16.

Now fix the "bell and battery" switch to the board by a screw through its eye, the screw being about 1 inch from the right edge, and about $1\frac{1}{2}$ inches from the bottom edge of the board; and allowing the switch to swing freely. At an equal distance from the central screw, put two mushroom-headed screws, so that the one is above, and the other below the straight arm of switch, the upper one keeping it from hanging vertical as it would do, if free, owing to the heavier bent end. About $\frac{5}{8}$ inch is ample distance between these two screws, which are marked C and D in Fig. 16. In a parallel line with the eye which you placed on left-hand arm of "telephone" switch, and at a distance of $\frac{3}{4}$ inch from it screw another eye in, precisely similar, so that the two appear as at G and H, Fig. 16.

Fixing "bell and battery" switch.

The eye G together with the screw under right arm, and the three screws of "bell and battery" switch should all be fixed as shown in Figs. 9 and 11; the hole being enlarged on the back of board by a rose bit, to allow room for twisting the wire around the screw. Now with a narrow gouge cut a channel a $\frac{1}{4}$ inch deep in the wood at the back of the board, between C and right hand screw of brass slide mark E, which screw should be shorter than the others, as it must not project in front or it will not fasten the slide securely.

Arrangements for eyes and screws.

From the screw F cut a channel vertically upwards to edge of wood; from the centre screw A cut one horizontally to right hand edge, from the screw G cut out one to the left hand edge, and from screw D cut one vertically down to the edge. Now take five short pieces of the same insulated wire as you use for your "line," and with your knife scrape off $1\frac{1}{2}$ inches of the cotton or gutta-percha from each end. Lay one in the channel between C and E, and twist the ends around the shanks of the screws two or three times, as shown in Fig. 9. A little solder will make the joints more secure. In the same way fasten a wire to A, F, D and G, leaving the other ends sticking out beyond the edge of wood. Fill in the channels all around the wires with a melted paraffin candle, and then glue a piece of paper over the whole back of the wood. To the eyes of G and H must now be fastened the two telephone wires, and as these should be long and pliable enough to allow the telephone to be freely handled and held to the mouth

Channels for wires.

Attachment of wires.

Filling in channels.

or ear without breaking the connections, they are generally made of a special kind, the two wires being woven together with fine silk, although kept insulated from each other. This special wire

Cost of wire.

can be purchased for 2d. a yard, and 1 yard is sufficient for each telephone. At each end separate the two wires and fasten them one to each of the telephone terminals as I described in the previous chapter, and the other two ends to G and H by twisting one around each eye, and fixing them with a little solder. (See Fig. 11.) Hang the telephone on

Ring for hanging Telephone.

the hook of switch, by a small picture-ring screwed into the end of the telephone, clear of the magnet and terminals, and the switch-board is complete.

You will observe that the whole of Fig. 16 is merely a diagram, and not therefore made to any scale. The two stations are made respectively right and left handed, to show distinctly

Switch-boards: how to be made.

all the connecting lines, but you will of course make both your switch-boards alike as described and shown in No. 1 station. The hook of the "telephone" switch is for the same reason shown on one side, but it really faces you as in Fig. 7.

Bells.—Now let us see how to make the bells; for I presume you would like to make them for yourself rather than purchase the

Electric bell.

ready-made article, which would cost, at the very least, 4s. 6d. or 5s. An electric bell consists of an electro-magnet, which, by alternately attracting and releasing a hammer causes it to strike against and ring a bell. But some will ask, "What is an electro-magnet?" and as this is one of the most important things in the practical application of electricity, I will in a few words explain it. If a coil of insulated wire be wound

Electro-magnet.

around a piece of soft iron—and by "soft," I mean common iron, which has not been hardened or tempered in any way—and then an electric current is sent from a battery through the wire, the soft iron instantaneously becomes converted into a strong magnet, remaining so as long as the electric current flows around it; but the moment the current ceases, then the iron as instantaneously loses its magnetism. Thus you see an electro-magnet differs from the telephone, for there the permanent magnet creates an electric current, and so magnetism produces electricity; here the electric current makes the magnet, and so electricity produces magnetism. The first thing, therefore, for the

bell is an electro-magnet. To make this, get a piece of round iron $\frac{1}{4}$ inch in diameter and about 5 inches long, and heating it blood-red in the fire, bend it round to the shape of a horse-shoe, with the ends about 1 inch apart centre to centre, and then let it cool *gradually* by leaving it in the ashes. Now take two wooden reels or bobbins, each about $1\frac{3}{8}$ inches long—ordinary cotton reels will do—and enlarge the holes until they will allow the ends of the iron to fit tightly into them. At the same place from which you obtained the fine wire for your telephones, purchase some No. 28 B.W.G. wire, also covered with cotton or silk; its price is about 6d. per ounce, and two ounces will suffice for one bell. Wind half of it neatly around one of the bobbins, and then, in the contrary direction, wind the remainder around the other bobbin. I have shown the direction clearly in Fig. 12. It is most important that you should do this correctly, for when the iron becomes transformed into a magnet, its north and south poles are also determined by the direction of the current.

How to make electro-magnet.

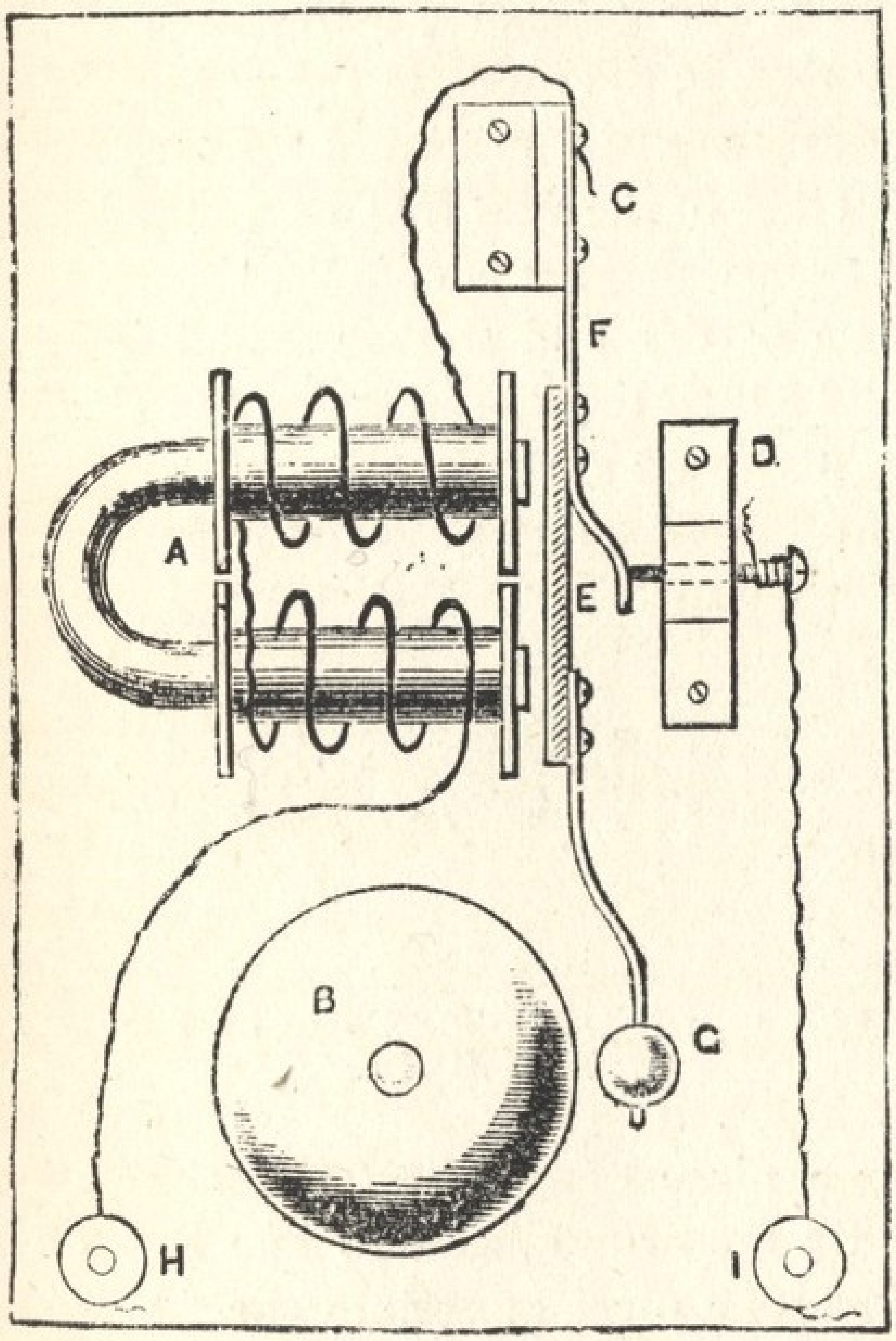


FIG. 12.—DIAGRAM EXHIBITING CONSTRUCTION OF ELECTRIC BELL FOR TELEPHONE. Half size.

To find out which is north, Ampère's rule, which is easily remembered, is this. Supposing a man to be swimming in the wire along with the current, and that he is looking down on the piece of iron which lays at right angles beneath him, then the north pole of the iron would be at his left hand, and the south pole at his right hand. Applying this rule to the horse-shoe, you will see that if the wire is

Ampere's rule for determination of poles of magnet.

not wound around it properly, you would not obtain the two requisite poles to form the magnet. This will appear clearer if you consider the horse-shoe as straightened out, with the bobbins on it end to end, as if they were united into one ; then the wire should appear wound around both continuously, and in the same direction. When the wire is thus wound properly, it is immaterial to which end you apply the current, for as your horse-shoe has its two poles brought together, even if you reverse the direction of the current, you would certainly change the poles, but they would still act together in attracting the armature. Leave about 6 inches of the ends of the wire free, as you did with the telephone coil, and your electro-magnet is complete.

Completion of magnet.

For a board, take a piece of dry and well-seasoned wood 6 inches long, 4 inches wide, and ¾ inch thick, and fasten the electro-magnet to it by placing a small piece of wood across the top of the two bobbins, and screwing it down with two wood screws, as shown in Fig. 13. The position of magnet on the board is shown at A in Fig. 12, where I have omitted the bit of wood and screws, so that the direction of the wire coil might appear distinct.

Material for board.

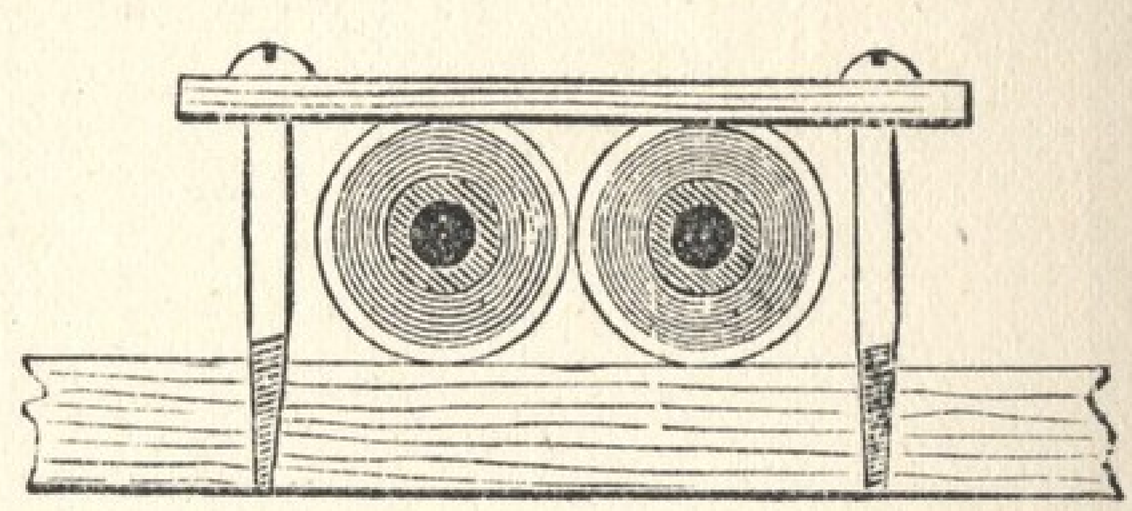


FIG. 13.—WOOD ACROSS TOP OF BOBBINS. Half size.

For the armature E, take a piece of soft iron 1⅞ inches long, ⅜ inch wide, and ⅛ inch thick, and to one end of it fasten by small rivets a piece of springy sheet brass F, about 2½ inches long, leaving one end of it clear for about an inch, and bending out the other end a little, as shown.

Iron for armature.

About ⅛ inch from this end must also be drilled a minute hole to rivet on a bit of platinum, or else the electric current which passes from the screw in D to the spring F at this point would burn the brass. At the end of the straight part of this spring make two holes about ½ inch apart. Should you find it difficult to make these holes and to fasten the spring to the armature, any working watchmaker would soon do it for a trifle. To the other end of E must be fastened in the same manner a piece of brass wire G, about 1¾ inches long, which at its

Platinum on armature.

far end is screwed into or soldered on to a little brass knob about $\frac{1}{4}$ inch in diameter, to form the hammer. Now out of a piece of hard wood—beech is the best—with your tenon-saw cut one piece, as shown at C, an end elevation of which is given at Fig. 14, and one piece, as shown at D, a side elevation of which is shown at Fig. 15.

Wood for armature.

To C must be screwed the straight end of the spring F by two small brass wood screws through the holes at a height equal to the distance which the centre of the electro-magnet is above the board. Then fasten C by two wood screws on to the board, so as to bring the armature parallel across the poles of the electro-magnet, and about $\frac{1}{8}$ inch off from them.

Attachment of spring to wood.

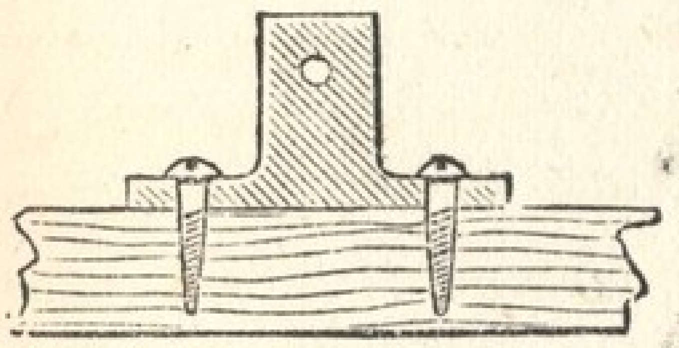


FIG. 14.—END ELEVATION OF C IN FIG. 11.
Half size.

Through the centre of D, at the same height, screw a thin round-headed brass wood-screw long enough to project beyond the wood at each side for about $\frac{1}{4}$ inch. If you make D about $\frac{3}{8}$ inch thick, then the screw would be $\frac{7}{8}$ inch long. Now fasten D to the board, so that the screw points towards the centre of the magnet and touches the bent end of F, where the bit of platinum is riveted.

Round-headed screw.

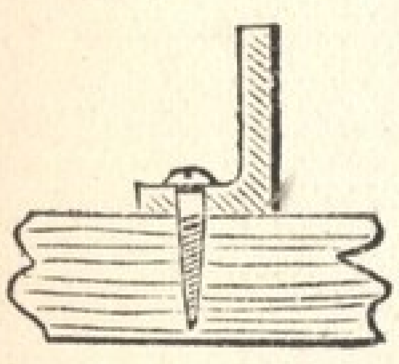


FIG. 15. — SIDE ELEVATION OF D, FIG. 10.
Half size.

For the bell B, you might for a few pence purchase an old gong out of an alarum clock, or a little brass hand-bell will do nicely if you take out its inside clapper, and fasten it, mouth upwards, by sticking the handle into a hole in the board, so that the edge is about $\frac{1}{8}$ inch off the knob G, the wire of which you can bend a little, to bring it level with the striking edge of the bell.

Bell, whence obtainable.

Now, for terminals, screw two large brass screws into the board at H and I. Around H twist one end of the bobbin wire, and connect I to the screw of D by twisting the ends of a short piece of wire around them. Finally, fasten the other end of the bobbin coil to the head of one of the brass wood-screws which holds the spring F to C, and your electric bell is complete.

Terminals.

To ring it, you must connect up one terminal to the "copper" of your battery, and the other terminal to "earth." Let us suppose you have done this, and that the terminal I, in Fig. 16, is joined by wire up to your battery, and H to "earth." Then the current would flow from I along the wire to the screw in D, passing to the end of which, it reaches at the platinum point the spring F; then it runs along F to the screw in C, around which is twisted the end of the bobbin coil, and so it finds its way through the whole of the coil around the horse-shoe to H, and loses itself in "earth." But the moment it flows through the coil, it converts the horse-shoe into a strong magnet, which attracts the armature E towards it, causing the hammer G to strike the bell B. But when the armature E is thus attracted towards the magnet, it at the same time draws the spring F away from the end of the screw in D, and thereby breaks the connection, stopping the flow of the electric current. The horse-shoe then loses its magnetism, and can no longer attract towards it the armature E, which, therefore, is pulled back by the spring F to its original position, when the platinum point again touches the screw in D; connection is then made, the electric current flows again, and, as musicians would say, *da capo*.

How to ring bell.

Influence of electric current.

Should a bell prove too loud for a room, a toy tambourine or small drum can be substituted for it. The screw in D will have to be adjusted so as to make and break the contact nicely. Also, should any of my readers prefer a single-stroke bell or gong in preference to the repeated and continuous ring, it can be easily done by screwing the screw in D up so as to keep its end always touching the platinum on F, and making the wire of G to spring slightly. Then, when the current is started, the electro-magnet draws the armature so sharply towards it that the wire G will spring the knob sufficiently to strike the bell once. It is a little fidgety to get the screw properly adjusted for this, and you may have to slightly alter the bend of the wire G.

Substitutes for bell.

Difficulty in adjustment of screw.

The bell should be fixed vertically on the wall, in the position shown in the sketch, with the hammer hanging down; and it is better to cover it over with a casing of thin wood or cardboard to keep out the dust.

Position of bell.

All that is now left for me is to describe how to finally connect

up and set in working order. First of all then, at a height of about 5 feet from the floor, fasten by two screws the switch-board in a vertical position against the wood-work of the shutter recess, or against the wall in any other part of the room that you may deem more suitable or convenient, and having your battery in good order, place it near. The bell will go nicely over the switch-board, and of course the closer you keep all three together the shorter your connecting wires will be, and the less trouble you will have in fixing them.

Setting in working order.

In Fig. 16 (No. 1 station) I have shown distinctly all these wires. The end of your "line" wire must be joined to the wire which is twisted around the central screw of the "bell-battery" switch at A. The carbon of your battery must be joined to the lower screw D of the same switch; the upper screw C you have already connected to the brass guide at E. The screw-eye H has no wire attached to its shank, but only one of the pliable telephone wires twisted around its eye; the other telephone wire being fastened in the same way to the eye of G. The wire from F must be connected to one of the terminals of the bell at I, and finally the other terminal of the bell, the wire twisted around the shank of G and the wire of the amalgamated zinc rod of the battery, must all three be connected to "earth"—that is, must be twisted around the nearest water or gas-pipe, marked K—these three "earth" wires need not each be fastened to the water-pipe; sufficient if one be led to the pipe and the other two twisted around this one, at the nearest and most convenient point. If, as is most likely, your water-pipe is outside the house, then you must lead the wire out of the window-sill by the same hole as your line wire. Wherever you thus join up two wires you must be careful to scrape about an inch off the insulating cotton or gutta-percha, and clean up the copper ends before twisting them together with a pair of pliers; and although not absolutely necessary, they will hold all the firmer if you touch them up with your soldering-iron.

Junction of "line" and battery wires.

Connection to "earth."

Mode of joining up wires.

Now let us see what takes place when No. 1 station wishes to speak to No. 2 station. He takes hold of the bent end of his switch A, and pushing it upwards, causes the other end to touch the screw D, then the electric current immediately flows from his battery B to D A, along the line

Communication between stations.

to No. 2, where the switch being in its normal position, it goes to C, and on to the brass guide E; but it does not stop there, for although the wire on which the telephone hangs is loose enough to slide up and down in the brass guide it is still always touching it; so the current goes up the wire to F, and then on through the bell I, ringing it, and finally loses itself in "earth" by the water-pipe.

Summons given.

No. 2, hearing the bell ring goes to his switch and answers back in precisely the same way; No. 1 of course having allowed his switch to go back to its hanging position against C whilst awaiting the answer. Both now unhook their telephones, allowing the little spiral spring to pull up the switch clear of F (thereby cutting off the bell) and causing it to touch H. No. 1, the first to ring up, speaks first, whilst No. 2 holds the telephone to his ear, and the currents now being no longer the strong ones from the batteries, but those generated by the telephone-magnets—the connections are "earth" K G, down one telephone wire, and around the telephone coil, up by the other wire to H, through the two arms of switch to E, thence on to C A, along the line to the other station to A C E H telephone coil, G K "earth." When the conversation is ended, both by hanging up their telephones, reconnect up their bells ready for another occasion. And now I think I have shown how I got my telephones to work, and but little more remains for me to say. Throughout I have endeavoured to make everything as simple as possible consistent with good working results, and therefore my readers will find ample room for improvements, and I have no doubt several will look with scorn upon my poor round-headed screws, and speedily substitute proper brass terminals, etc.

Reply to summons.

Change of currents.

Reconnection of warning bells.

One improvement I will mention, and it is this—the awkwardness of having only one telephone for both speaking through and hearing, can be got over by having two to each station, when one can be held to the ear, whilst with the other you can speak. To connect up the second, or "listening" telephone, instead of fastening to the eye of G, one of the wires of the first, or "speaking" telephone as stated above, you must join it direct to one terminal of the "listening" telephone, and then in its place connect up the other terminal of this "listen-

Utility of two telephones to each station.

ing" telephone to G. The current will then pass from G through both the telephones, first the "listening," then the "speaking" one, before reaching H. As the weight of the one telephone is sufficient for keeping down the switch, the "listening" one need merely be hung on an ordinary brass hook at the side, or anywhere near.

Position of "listening" telephone.

In conclusion, should any of my readers be desirous to follow up the subject, and learn a little more about this wonderful and

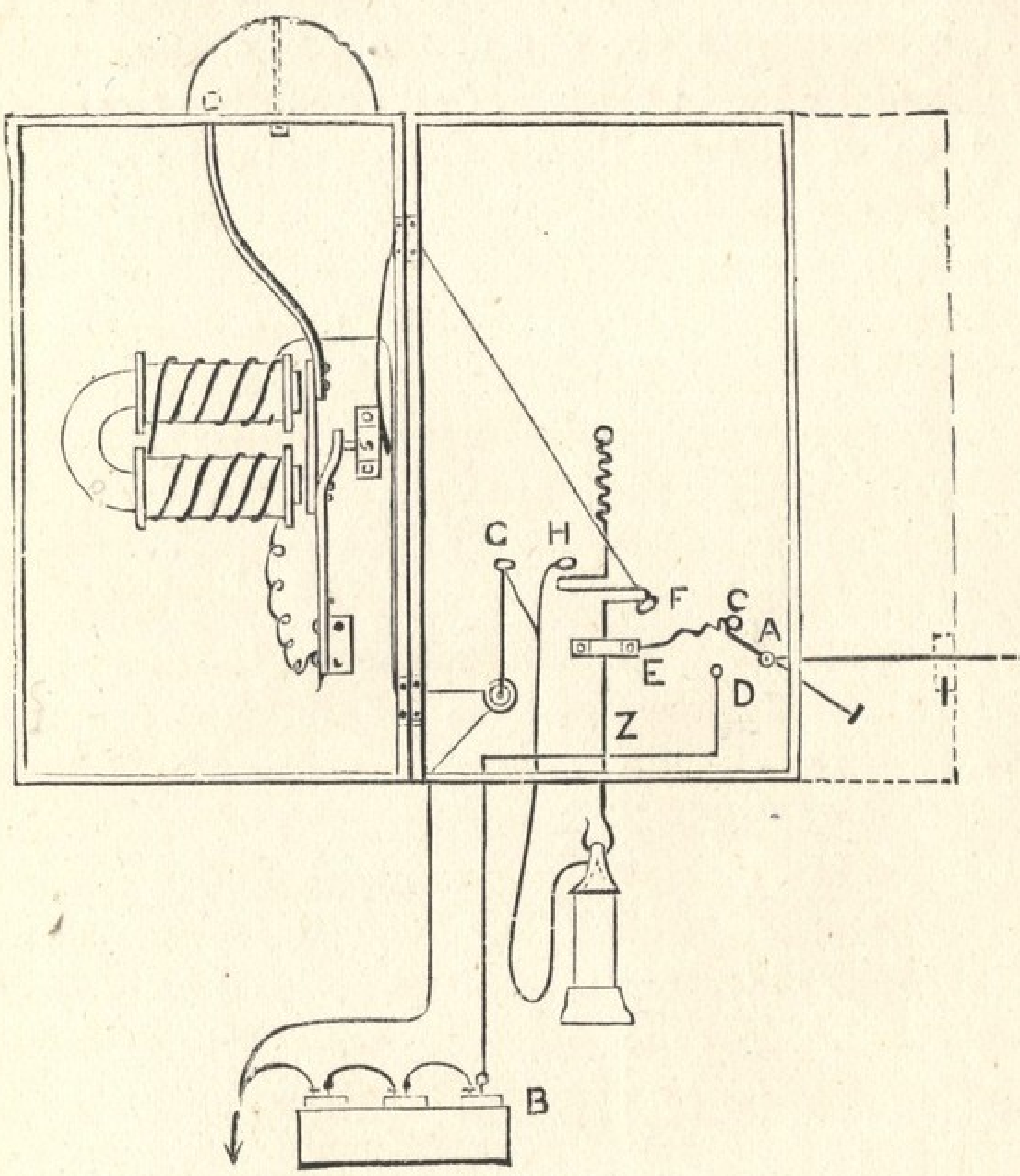
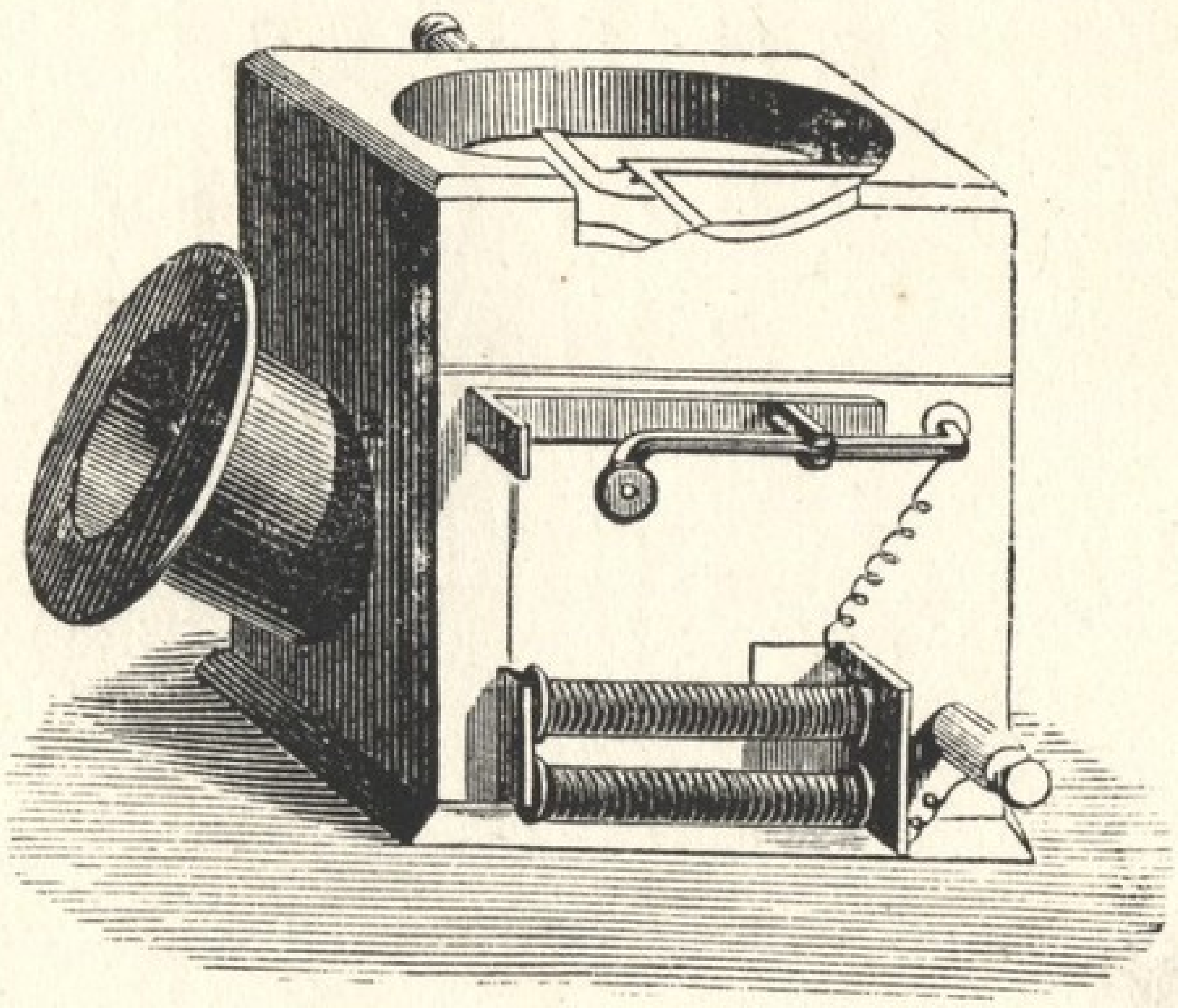


FIG 16.—MODE OF MOUNTING TELEPHONE SWITCHES.

interesting science, I can well recommend to their perusal a little book by Professor Silvanus Thompson, entitled "Elementary Lessons in Electricity and Magnetism," and then they will not rest contented until they have, by the addition of carbons or microphones, and mysterious induction coils, rendered perfect their telephonic stations.

Thomson on electricity and magnetism.

Thus far can I go, and no further; for, being a busy man myself, I have been forbidden the time necessary to go further and deeper into the subject in which I have sought to interest my readers. I can only add that I experienced considerable pleasure in planning and carrying out the first attempt, and, I fear, the last that I have been permitted and privileged to make in telephony, or the art of conveying vocal sounds, and therefore holding converse at a distance by the aid of electricity. It is, indeed, one of the wonders of the present day, and in regarding it one is often led to think with what astonishment any one of the last century would contemplate this and kindred matters, could he return to earth and be shown and told of all these things while, as Hamlet says, "revisiting the glimpses of the moon."



PART II.

THE DOMESTIC ELECTRIC LIGHT.

THE DOMESTIC ELECTRIC LIGHT.

CHAPTER I.

VARIOUS FORMS OF ELECTRIC LAMPS.

Result of recent exhibition of electric lights—The electric light at home—Classification of electric lamps—Characteristic features of arc lamps—Best types of arc lamp—Construction of semi-incandescent lamps—Types of semi-incandescent lamp—Principle of incandescent lamp—Exclusion of air from carbon—Best forms of lamp—Rivalry of Swan and Edison—Edison and Swan Electric Light Company—Cost of Swan lamp—Facts concerning Swan lamp—Cost of production of light—Lighting from battery at home difficult—Little lamps of eight-candle power—Construction of Electric Novelty Company's lamp—Connection with battery—Not possible to make lamp at home—Bunsen cell: its construction—Charge of porous cell—Treatment of zinc cylinder—Covering zinc cylinder with mercury—Carbon block—Making up battery of cells—Coupling cells in series—Why cells are thus coupled—Duration of current from Bunsen battery—Renewal of generating power—Test of strength of nitric acid—Battery requires daily cleansing—Bad effects of fumes from battery—Inefficiency of batteries for electro-plating and electric bells—Fuller's constant battery—Dale's bichromate battery—Urquhart's bichromate cell—Plan for making cheap battery—Charge for cell—Stoppage of fumes—Failure of platinum wire—Importance of platinum wire to amateur—Mode of making platinum incandescent lamp—Wooden base—Standard of copper wire—Lever and supporting pillar—Contact parts: how treated—Test tube as shade for light—Working of the lamp described—Adjustment of platinum wire to current.

Result of recent exhibition of electric lights.

THE collection of electric lights exhibited in 1882 at the Crystal Palace naturally awakened in the minds of many persons, in both town and country, the desire to possess the means of enjoying the light from an electric lamp in their own homes. Hitherto the means to gratify such a desire

had been so costly and troublesome as to practically render its attainment impossible to all except those who are wealthy. But then the coveted treasure was brought within the reach of most persons, and I give here a description of the various ways and means as they then existed.

The electric light at home.

I will not stay to examine the claims of rival makers of electric lamps, nor to compare the respective merits of the various lamps then before the public. It is now generally understood that these lamps are divided into three classes —(1) Arc lamps; (2) Semi-incandescent lamps; (3) Incandescent lamps. In the arc lamps the carbon candles are consumed in air by a kind of fretting of the two points by the force of the electric current, the fretted and highly luminous particles being consumed between the two carbon points in the form of a double arc of light. The best known types of this lamp are those of Siemen's, the Brush Company's, and the Crompton lamps. This kind of lamp requires a current of great force, only available from those large generators of electricity known as dynamo-electric machines. They are, therefore, inadmissible here, except to claim a passing notice in comparing them with others. In the semi-incandescent lamps the carbon is also consumed in air, but only one carbon is thus consumed, and this not entirely in the form of an arc. A pencil of carbon is made to rest against a block of carbon in the upper part of the lamp, as in the Werdermann lamp; or against a cylinder of copper, as in the Joel lamp. When the electric current is made to pass through the carbon pencil, its point becomes incandescent, and glows with a white heat, whilst at the same time small particles of glowing carbon are fretted off, as in the arc lamps. In the incandescent lamps a filament of carbon is made to glow with a white heat under the force of the electric current, but it is not allowed to consume away. This is achieved by enclosing the filament in a little glass globe, exhausting all the air in the globe, and then sealing it hermetically. As carbon cannot consume without a supply of oxygen, and this supply (from the air) is cut off, the filament may be kept at a white heat for a very long time, even hundreds of hours,

Classification of electric lamps.

Characteristic features of arc lamps.

Best types of arc lamp.

Construction of semi-incandescent lamps.

Types of semi-incandescent lamp.

Principle of incandescent lamp.

Exclusion of air from carbon.

without showing the least sign of being burnt away. There were many forms of this lamp in the market; the best known bearing the names of Swan, Edison, Maxim, Lane-Fox, and the British lamps. All used the carbon filament in a tiny glass globe, and differed only in the form and quality of the filament and its attachment to the connecting points of the line, therefore we will not discuss their merits, but select the Swan lamp as a type of the whole for our purpose here.

Best forms of lamps.

Mr. Swan, of Newcastle-on-Tyne, and Mr. Edison, of Menlo Park, New York, U.S.A., were the two rival claimants for the honour of solving the problem of applying the electric light to domestic purposes by the invention of the incandescent lamp. Without attempting to advocate the claims of either, we need only say that the question has long since been settled, and that the incandescent electric light is the domestic light of the present day. The Edison-Swan United Electric Light Company and their agents will now fit up their system wherever required, or sell lamps alone for the purpose. In 1882 we could not get one of those lamps for less than 25s. each, but not long after they were sold at 5s. each, and are now to be bought for 1s. 9d. As it is a matter of fact that many persons at that time deceived themselves by buying one of the Swan lamps, thinking to get the light also without any further outlay, it will be well to state a few facts here concerning them, to prevent further mistake. An average Swan lamp then gave a light of from sixteen to twenty sperm candles if supplied with enough electric current, and if the necessary current for this purpose is to be generated in a Bunsen battery, we shall need fourteen Bunsen cells of quart size connected in series—that is to say, in file one after another—to light a twenty-five volt sixteen-power candle lamp. Let us look at the probable cost of this. Taking the cost of each cell at 4s. 6d., and lamp with holder and switch at 5s., the total cost will be £3 8s. There is a great difference between this and the cost of maintaining an electric light at original prices, when a greater number of cells were required, or supposed to be required, and lamps with the necessary fittings cost double the money. But this may now be regarded as belonging to ancient history.

Rivalry of Swan and Edison.

Edison and Swan Electric Light Company.

Cost of Swan Lamp.

Facts concerning Swan Lamp.

Added to this is the cost and trouble of charging and cleaning the cells, and an intolerable nuisance arising from battery fumes, enough in itself, independent of cost, to dissuade an amateur from undertaking such a task. Clearly, then, we could not think of lighting our homes with the Swan lamp by current derived from battery power, and had to await the time, not very far off, when they could be lit from mains of current generated by dynamo-electric machines maintained by electric light companies. As the other incandescent lamps above mentioned require similar conditions to work them, we will dismiss them altogether.

Lighting from battery at home difficult.

But we were not entirely left in the dark, for we could get little lamps giving a light of eight-candle power, with a current from six Bunsen cells. from the Electric Novelty Company, *Strand*, *London*, at 10s. 6d. each lamp, or an outfit of one lamp and its battery for 40s. This company apparently no longer exists. The form of this lamp is shown in the subjoined sketch; its construction is as follows:—A thread or filament of some carbonised material is bent into the form of a loop, the two ends of which are attached to two thin wires of platinum, and these are embedded in the glass stem of the lamp globe, this globe is then placed in connection with an air pump, and all the air is sucked from its interior, then the orifice is hermetically sealed by fusing the glass closely around the conducting wires. The two loops of the conducting wires are connected with the terminal poles of the battery, and the current from six quart cells of Bunsen's

Little lamps of eight-candle power.

Construction of Electric Novelty Company's lamp.

Connection with battery.

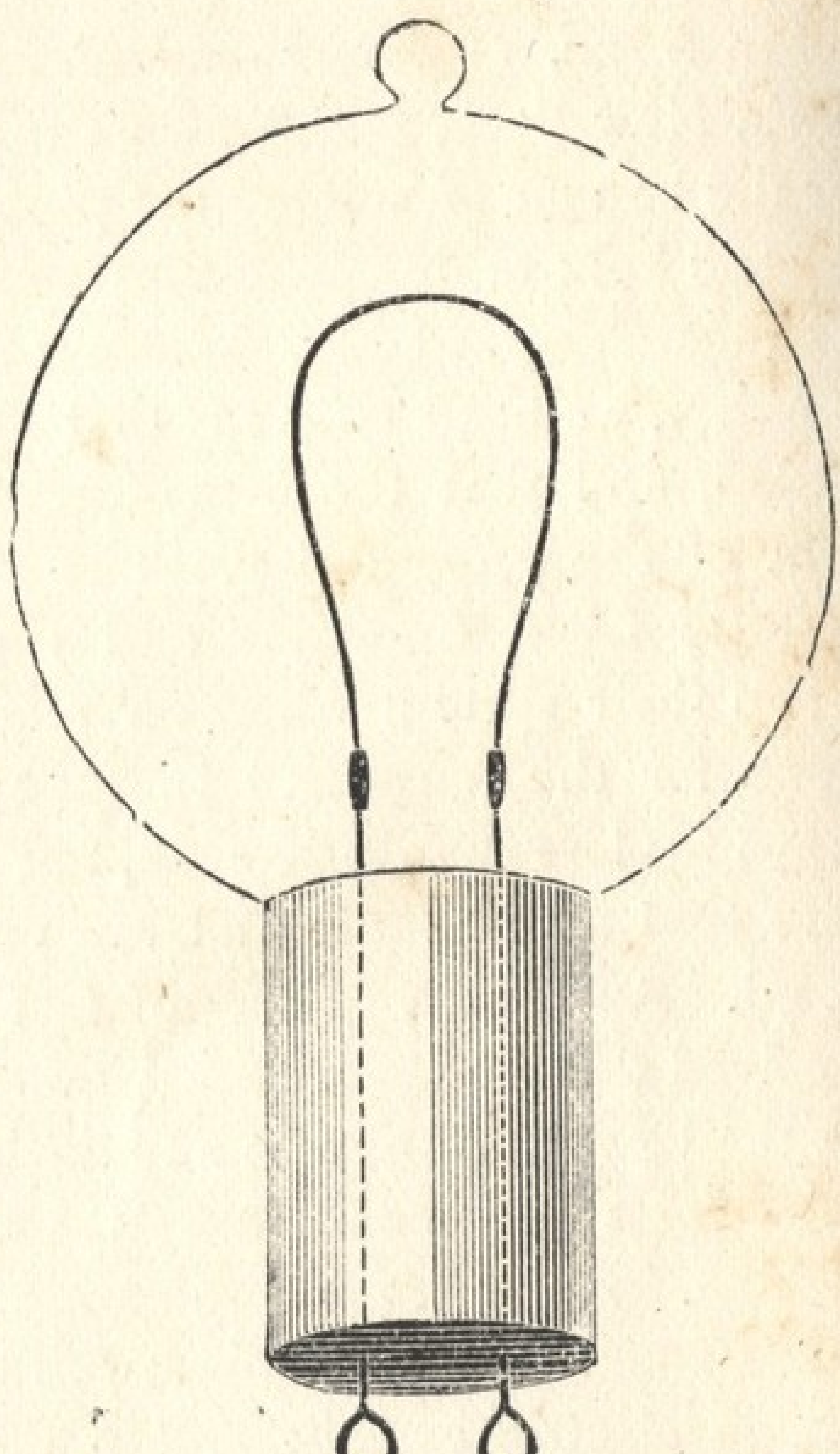


FIG. 1.—ELECTRIC NOVELTY COMPANY'S INCANDESCENT ELECTRIC LAMP.

battery heats the carbon filament to an incandescent condition, giving a light said to be equal to that from eight sperm candles.

It will be easily understood that this form of lamp cannot be manufactured at home, hence we have not entered into the minutiæ of its construction; but a few words respecting the battery may be acceptable. The Bunsen cell, Fig. 2, is composed of an outer containing cell of stoneware, into which loosely fits a cylinder of zinc, and a cell of porous earthenware within this in which is placed a square rod of carbon. The porous cell is charged with strong nitric acid, and the outer pot or cell with a mixture of one part sulphuric acid (oil of vitriol) in eight parts of water. The zinc cylinder must be well amalgamated with mercury, and this should be done as follows: First clean the zinc by immersing it a short time in the battery mixture above mentioned, and brushing with a hard brush (a coachman's carriage or spoke brush is a handy tool for this purpose); when it has been thus cleaned, roll the cylinder in a baking dish in which has been placed an ounce or two of mercury (quicksilver). If the zinc is clean it will be quickly covered with mercury on the outer surface, brush this well over and sweep some of the mercury into the inside of the cylinder with the brush, continue sweeping it in and brushing it until all the zinc has been made bright with mercury, then brush off all superfluous drops, and place the amalgamated cylinder in its place in the outer cell. Now put the carbon block in the porous cell, and take care in charging it with

Not possible to make lamp at home.

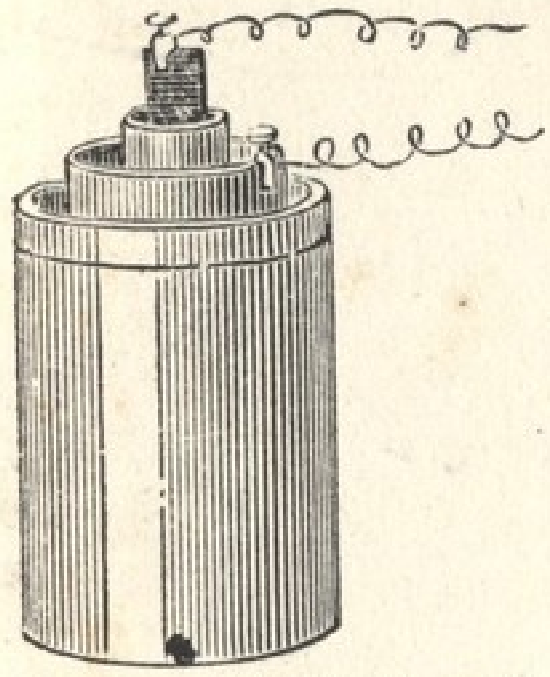


FIG. 2.—BUNSEN CELL.

Bunsen cell: its construction.

Charge of porous cell

Treatment of zinc cylinder.

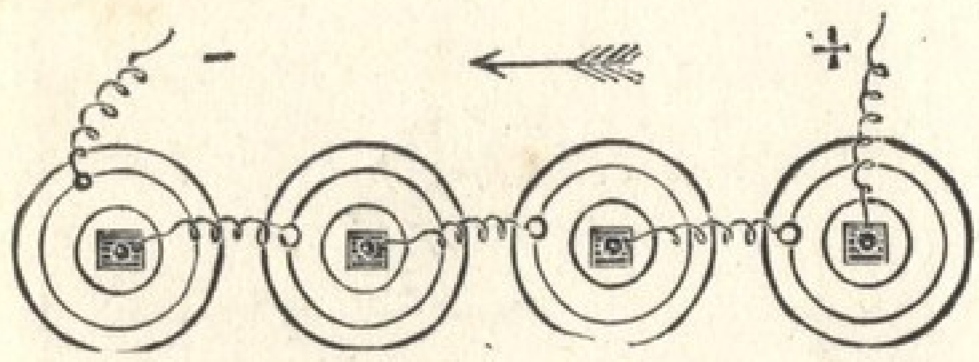


FIG. 3.—COUPLING CELLS IN SERIES.

Covering zinc cylinder with mercury.

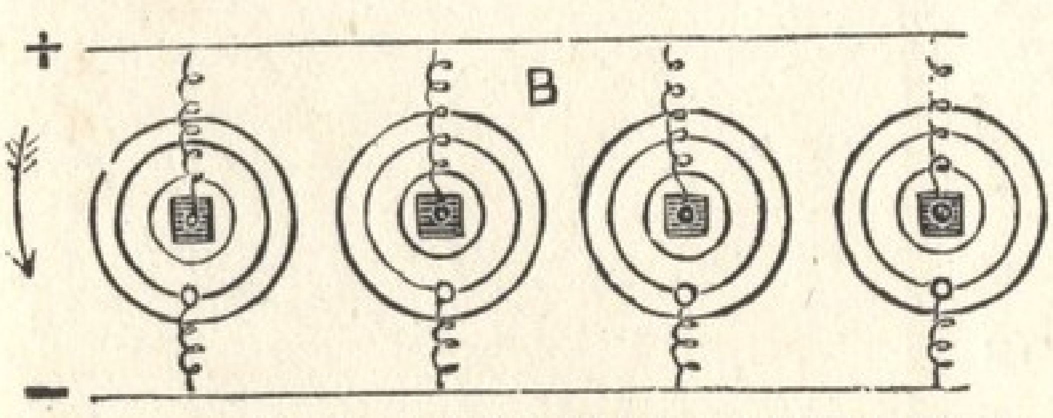


FIG. 4.—CONNECTING CELLS IN PARALLEL CIRCUIT.

Carbon block.

the nitric acid, not to spill any of the acid on the outside of the cell nor fill it above the intended line of the acid mixture of the outer cell. Put this cell in its place, and then charge the outer cell with the acid mixture, then clean and fix the binding screws to carbon and zinc ready for work.

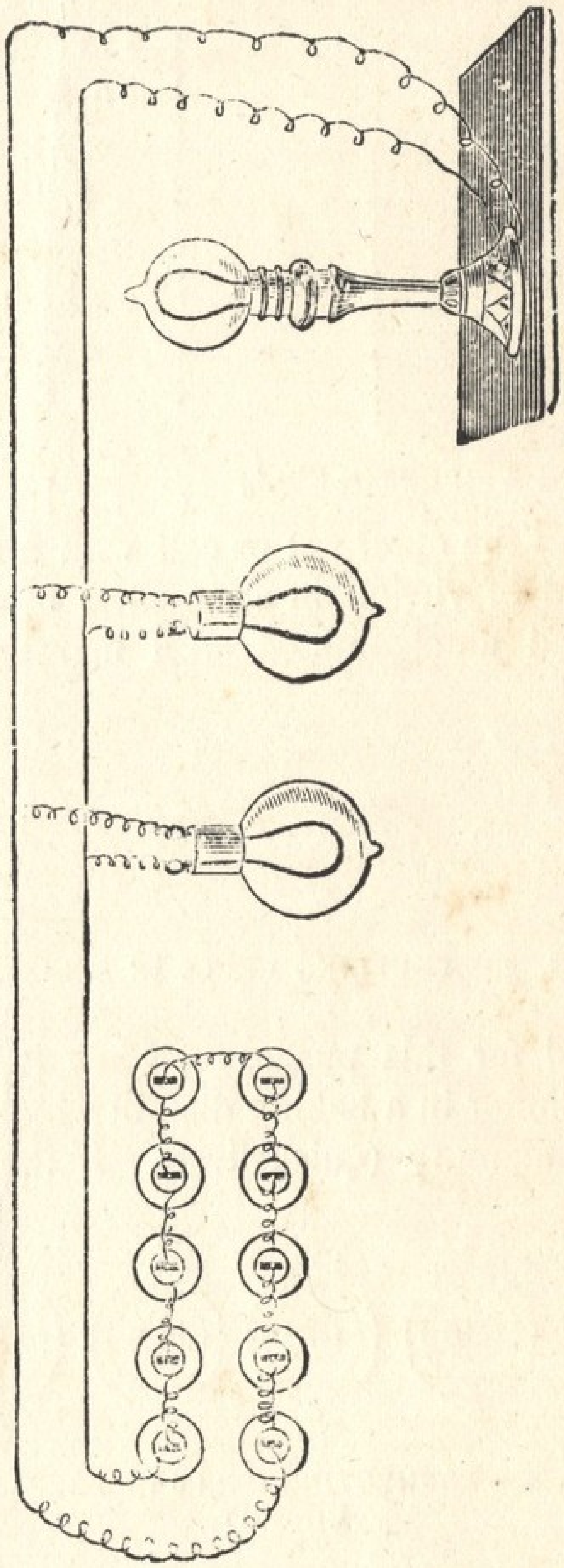


FIG. 5.—METHOD OF CONNECTING BATTERY AND LAMP IN CIRCUIT.

Making up battery of cells.

There are two distinct methods of making up a battery of cells: one being known as coupling them in "series," the other as joining up in "multiple arc," or "parallel circuit." To couple them in "series"

Coupling cells in series.

(Fig. 3) we connect the zinc of one cell with the carbon of the next, and so on through the long string of cells forming the battery; joining them in "multiple arc" is the converse of this arrangement, all the zincs being connected to one line wire and all the carbons to another. This is graphically shown in Fig. 4. By the first arrangement the battery is given "pushing power," or the ability so to speak of overcoming resistance in the circuit, a property nearly analogous to high pressure in water and steam; by the second we increase the volume or quantity of electricity generated in a given time, and it finds its

Why cells are thus coupled.

analogy in a large boiler filled with steam at a low pressure. In connecting up a battery of cells for the electric light, we invariably couple them in series to overcome the resistance of the lamp carbons; but the number

of the lamps connected with the battery is limited to two, or at the utmost to three. The arrangement of lamps is shown in Fig. 5.

The Bunsen battery will supply a vigorous current for four hours continuously, after this its force diminishes during the next four hours, and on such work as this we cannot hope to get effective work for a longer period than six hours. At the end of this time the cells must be taken to pieces, the zinc cylinders washed, brushed, and reamalgamated, the binding screws, clamps, and wires cleaned with emery cloth, and the carbon blocks, cells, etc., rinsed with water. It is best to dip the brush in the battery mixture and brush the zincs with it before they are amalgamated, this will use up a part of the mixture. Before recharging the cells this deficiency must be made up by pouring fresh acid and water into the pitcher with the old mixture and thus refresh it. The nitric acid should be poured from the cells into a jug, and be used again if it is not exhausted of its properties ; if it pours out from the cells green and fuming, it is all right ; if it pours out nearly black, it is almost exhausted ; but if it has changed from this latter tint to a yellowish liquid or one free from colour, it is exhausted, and fresh acid must be put in the cell with the carbon. The process of cleaning must be gone through immediately after each time of using the battery, and this must be made up afresh each night just before the light is required. Whilst the battery is at work it gives off dense brown nitrous fumes from the inner cell, which have an offensive odour, and are deleterious to health. Various expedients have been adopted to nullify the effects of those fumes. The cells have been put in a box, and a sheet of blotting-paper saturated with ammonia has been spread over them, or little boxes of ammonia carbonate put in with the cells, but the best plan is to put the box and its contents in an out-house or shed, and lead the wires from the battery into the house, in this case the line wires should be large and offer as little resistance as possible to the current.

Duration of current from Bunsen battery.

Renewal of generating power.

Test of strength of nitric acid.

Battery requires daily cleansing.

Bad effects of fumes from battery.

The nuisance arising from the noxious fumes of this and the Grove battery has led many persons to devise other forms of electric generators which should be free from the objectionable

features above mentioned, and yet be powerful enough to produce the electric light. The quiet and inoffensive batteries used in electro-deposition, and in doing such work as ringing electric bells, are altogether ineffective for this work. We have therefore to turn our attention elsewhere, and in doing so find that those batteries in which bichromate of potash does duty instead of nitric acid, promise to fulfil the first requirement; they are also powerful, but, like many other fickle jades, they are inconstant and liable to fail within at most an hour after being set up. Many methods have been devised by electricians and chemists to overcome this defect, hence we have the constant battery of Mr. Fuller, where the position of the elements are reversed, a rod of amalgamated zinc going in the porous cell with a little mercury, and a plate or carbon in the outer cell, the first being charged with the acid mixture, and the other with a saturated solution of bichromate of potash acidulated with one-fifth of sulphuric acid. This battery has been used with some success, but to be efficient the outer cells must be large, two carbon plates must be used, and two plates of rolled zinc instead of a rod of cast zinc. Any good constant bichromate battery may also be used for this purpose under similar conditions to that given for the Fuller cell. Mr. Urquhart has also described a constant bichromate cell in "Design and Work," of August 20, 1881, which has been said to be most effective for the electric light, but as I have not tried it I cannot say anything about its effectiveness. The following modification of a plan for making a cheap battery may be found useful in making up a battery for the electric light. Put an ordinary porous pot in the centre of a quart stoneware cell, and pack the space around with a mixture of equal parts by weight of iron turnings or borings and peroxide of manganese, using a strip of iron hoop instead of a zinc plate for the positive element. This cell is to be charged with bichromate solution as prepared for the Fuller cell. Now get a thin strip of carbon to go in the porous cell, and charge this cell with a mixture of one part nitric acid to ten parts of water, cut a barrel bung in two and fit them in the top of the porous cell, and on each side of the carbon so as to seal it in the

Inefficiency of batteries for electro-plating and electric bells.

Fuller's constant battery.

Dale's bichromate battery.

Urquhart's bichromate cell.

Plan for making cheap battery.

Charge for cell.

cell and prevent any fumes from rising, or a wooden cover may be made for the purpose. In the original plan (with platinised silver in the porous cell) a battery of six cells has been said to light up an incandescent lamp, and work for eight days without renewal.

Stoppage of fumes.

Nearly all early experimenters with the incandescent electric lamp have tested the efficiency of a thin wire of platinum, relying upon its known infusibility, even when kept at a white heat by ordinary methods of heating. But platinum wire has failed when heated by a current of electricity, and the thin spiral or loop has frequently suffered disruption from the current when the light has been at its best. Not a month since I saw a 5s. lamp prove a dead loss to its owner by the fusing of the platinum loop under the current of four Bunsen cells of quart size, weakly charged, and I hear that this is not a solitary case. If this material could be safely used it would prove a boon to the amateur lamp-maker, since the fine platinum wire is within his reach, but the carbon filaments are unattainable by him. The following method of making a platinum incandescent lamp (published in a letter to *The Mechanical World*) promises to be a good one, within the means and skill of almost every person. The necessary materials are a disc of wood, ¾ inch thick, and 2 inches diameter, 6 inches of No. 10 B. W. G. copper

Failure of platinum wire.

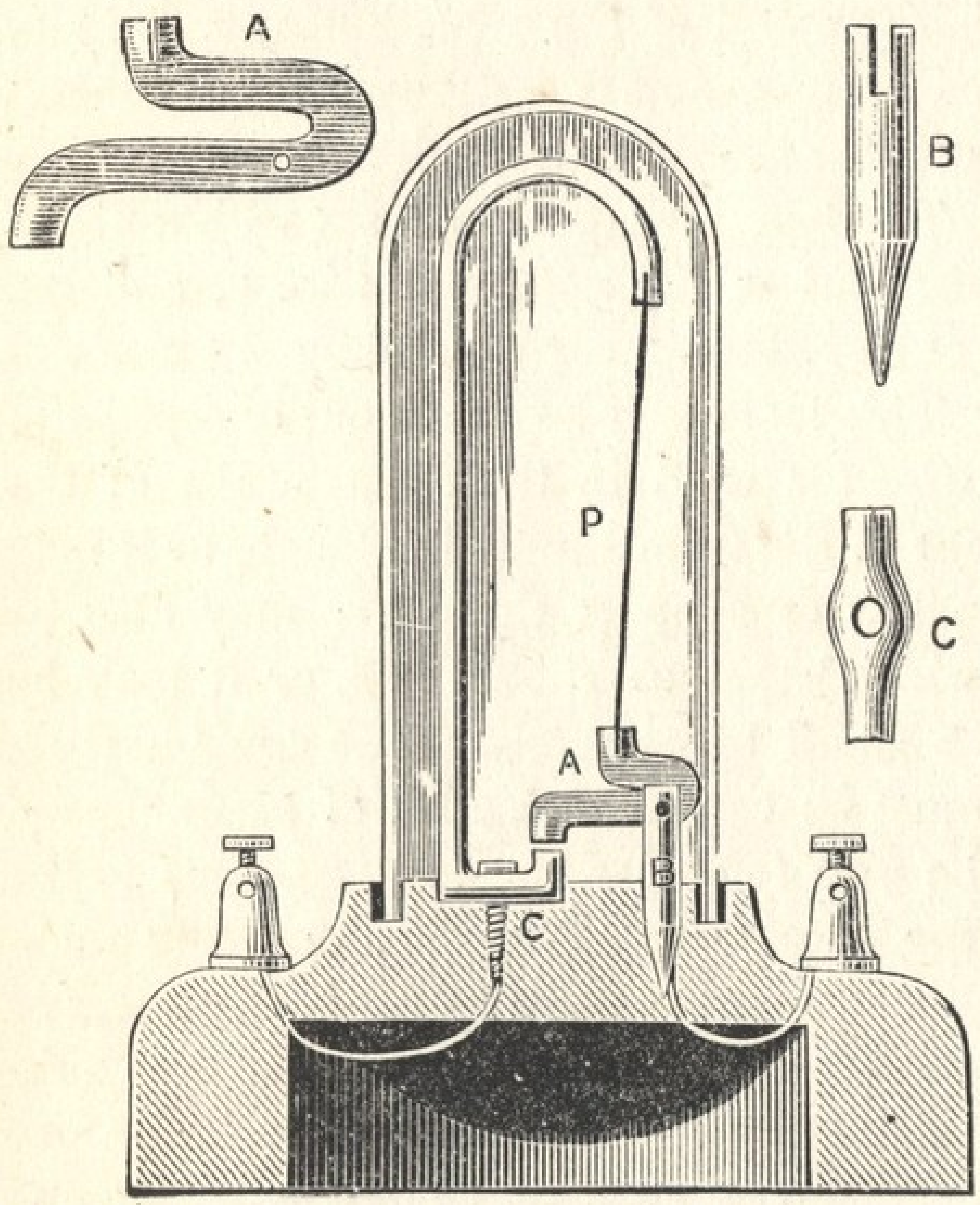


FIG. 6.—SECTION OF PLATINUM INCANDESCENT ELECTRIC LAMP.

A, Lever to short-circuit current when the platinum wire is overheated; B, Pillar to support lever; C, Foot of standard holding platinum wire; P, Platinum wire.

Importance of platinum wire to amateur.

Mode of making platinum incandescent lamp.

wire, 3 inches of No. 40 platinum wire, and a large test tube. The form of lamp and its construction is shown in the sketches, Fig. 6, which have been altered a little in detail from the original sketch to suit less skilful persons than its designer. The base may be neatly turned up out of a piece of hard wood and hollowed as shown, or made out of any odd bit of wood and left flat.

Wooden base.

The standard of bent copper wire may be fixed to the base by a foot C, made by flattening one end of the wire, boring a hole to receive a small screw, and turning up a small contact piece; or it may be brazed to a small brass stud made to screw into the base. The bent part must be slit with a file or hack-saw to clip the upper end of the platinum wire P, and the lower end of this wire must be held in a corresponding slit made in the lever A. This lever may be made out of a piece of the copper wire (as used in the construction of the standard), bent to the form shown in sketch, or it may be made of brass. The pillar to support this lever may also be made out of a bit of the wire shaped as shown at B, or it may be made from a small brass screw. The contact parts of A and C must be tipped with a bit of platinum foil soldered on, and it will be well to solder the leading wires to the pillar B and the foot of the standard C, afterwards passing them through holes in the base and attaching them to the binding screws on each side. A large test tube inverted over the working parts of the lamp and held in a circular groove at the bottom, forms a neat shade and protection to the light. Test tubes suitable for this purpose, $1\frac{1}{2}$ inches in diameter, may be obtained through any electric lighting company or firm for less than 2s. per dozen.

Standard of copper wire.

Lever and supporting pillar.

Contact parts: how treated.

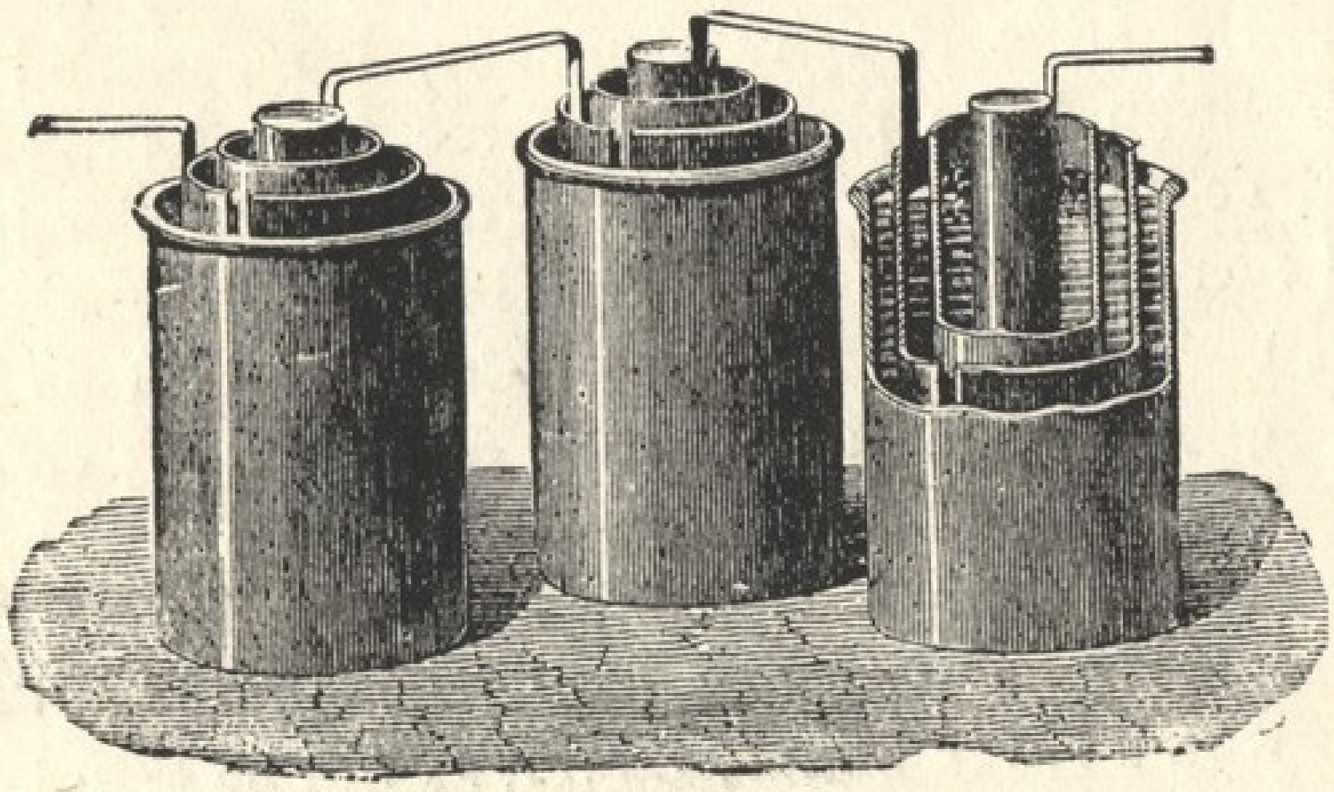
Test tube as shade for light.

The working of this lamp is as follows: Connect the two binding screws with the two poles of a powerful battery; if the current is strong enough, it will heat the platinum wire white hot, and it will then give out dazzling white rays of light, whilst the wire will expand and lengthen. If the lever A is free to move, and has been properly adjusted, it will drop slowly, and nearly touch the foot C. A little more current, such as would fuse the platinum wire, will cause it to lengthen still further; A will then touch C, and short-circuit the current until P has cooled

Working of the lamp described.

enough to draw A away from C, when P will again get white hot. If the current is not strong enough, the platinum will only get red or yellow, and emit a feeble light, and if it then short-circuits the lamp, the wire must be shortened. It will thus be seen that the platinum wire may be adjusted to bear any current short of that necessary to fuse the wire, and this accident may be prevented by adjusting the wire to short-circuit through A and C when the wire gets dangerously hot. The light from this lamp will not be equal to that from a carbon lamp, but it has the merit of being cheap, easy of construction, and easily repaired; it may also be worked with a few Fuller or other bi-chromate cells.

Adjustment of platinum wire to current.



BUNSEN'S BATTERY.

CHAPTER II.

THE LOW-POWER SWAN LAMP.

Electric force required by large Swan lamp—Lamps requiring weaker current—History of the Swan lamp—Necessary vacuum in globe—Effect of air on carbon—Causes of disintegration—Experiment on carbon threads—Carbonized crochet cotton—Its fineness and hardness—Success of experiments—Cause of brilliancy of light from carbon loop—Form of filament in low-power lamps—Shortening of arch necessary—Number of cells for working two or more lamps—Battery for several lamps—Bichromate battery for small lamps—Prices of lamps—Coil for support of Swan lamp—Suitable holder for lamp—Stand for lamp—Design for wooden lamp-stand—Arrangement suitable for fixed lamp—Regulation of intensity of light—Tap as pivot of switch—Dynamo-electric machine for amateurs.

IN the preceding chapter, in my remarks prefatory to the description of an Electric Lamp sold by the Scientific Novelty Company, I mentioned that the Swan lamp required a force from fourteen Bunsen cells to work it. It must be distinctly understood, however, that I therein referred to the large lamp then manufactured by the Swan Electric Light Company. This lamp required a constant pressure of at least 25 volts to give a light of 16-candle-power; but lamps of lower voltage and lower candle-power can now be obtained from all manufacturers of electric lights. The lamps can be worked with a lower battery power, as will be seen later; but before I go into these particulars, which cannot fail to present many points of interest to all amateur electricians, and especially to young beginners, I will take a passing glance at the history of the Swan lamp.

Electric force required by large Swan lamp.

Lamps requiring weaker current.

Whilst Mr. Edison was conducting his experiments on the use of platinum in electric lamps, Mr. Swan, of Newcastle-on-Tyne, was turning his attention to the maintenance of carbon in an incandescent condition under the influence of the

History of the Swan lamp.

electric current. Twenty-two years ago he sought to produce the electric light by heating a thin strip of carbon under a glass shade, exhausted of air; although he failed in that experiment through a breakdown of the apparatus employed by him, he obtained an insight into the principles of incandescent electric lights, and, subsequently to this, renewed his experiments. An interval of seventeen years had given him some new appliances, the most important of which, the Sprengel air-pump, enabled him to obtain a much higher vacuum for his experiments than could be produced by the common air-pump. This high and complete vacuum in the glass globe which contains the carbon, is absolutely necessary to the production and maintenance of the electric light therein. Let the smallest quantity of air into the globe, and the glowing filament of carbon will flash up brilliantly, then crumble into dust. In the imperfect vacuum thus obtained by the common air-pump, Mr. Swan and others observed that the stout carbon threads then employed, wore away rapidly, obscured the glass with a kind of thick smoke or soot, and then broke. Mr. Swan concluded that this disintegration was due to two or three causes—first, the air was not entirely exhausted from the containing globe; second, the globe was not hermetically sealed; third, the carbon thread itself held air or a gas which caused its destruction when heated. Accordingly, in October, 1877, he had some carbon threads carefully enclosed in glass globes, the air perfectly exhausted, the threads raised to a white heat, and then the globes hermetically sealed by a glass-blower. This experiment was rewarded with success, but there was another matter or two requiring attention before the lamp could be considered perfect. The thick carbon available at that time required a very strong current of electricity to make it white hot, and it lacked an equal quality in all its parts. After a series of experiments with various vegetable fibres, Mr. Swan produced a carbon filament as fine as hair, from crochet cotton specially prepared and then carbonised. In 1879, whilst I was experimenting with a semi-incandescent lamp, Mr. Swan wrote that he was confident of success with incandescent lamps, and in 1880 he wrote the following concerning his new carbon: "The carbon is extremely thin—a mere

Necessary vacuum in globe.

Effect of air on carbon.

Causes of disintegration.

Experiment on carbon threads.

Carbonised crochet cotton.

hair—but wonderfully strong and elastic. This carbon is quite homogeneous, and almost flinty in hardness, and it becomes harder by use in the lamp ; the longer and the hotter it is heated, the harder it becomes. What degree of hardness it will ultimately arrive at is an interesting question. The carbon I use is not one-twentieth the thickness of the thinnest of the carbons formerly employed, and therefore one-twentieth of the current, costing one-twentieth the price, will produce in my thin carbons the same degree of luminosity as twenty times more current will produce in such carbons as were used in those ancient lamps."

Its fineness and hardness.

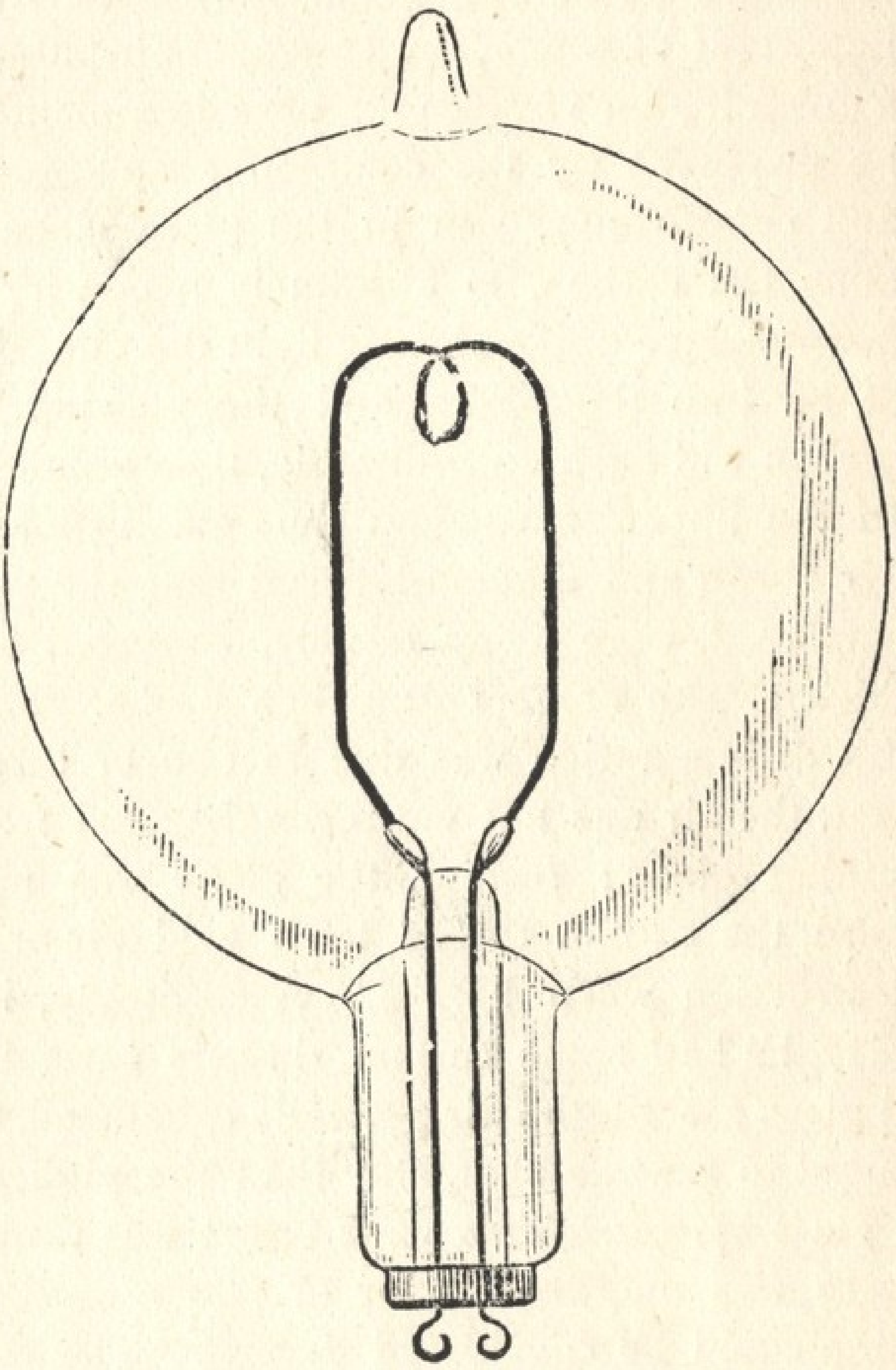


FIG. 7.—SWAN LAMP. 16-CANDLE POWER.

It will thus be seen that he successfully overcame the two last objections, and brought the incandescent electric light out of the secluded chamber of scientific interest into the larger arena of practical success. Those of us who were able to visit the Electric Light Exhibition at the Crystal Palace in 1882 could not but appreciate and admire the beautiful clusters of Swan lamps, whether seen in the splendid electrolier hung in the French Furniture Court, or under the pretty tinted glass bells on the stand of Messrs. Strode and Co. ; in the Picture Gallery, or in the Refreshment Rooms. Much of the peculiar brilliancy of this incandescent lamp appeared to be due to

Success of experiments.

Cause of brilliancy of light from carbon loop.

the intense centre of sparkling white light given out by the carbon loop, which is a distinguishing feature of Mr. Swan's large lamps (a sketch of one is given in Fig. 7), but Messrs. Siemens' agent at the Palace considers it due to the superior quality of the carbon, which enables it to bear a fraction more current than that in other lamps.

Form of filament in low-power lamps.

It will be seen on reference to Fig. 8, representing one of the low-power Swan lamps, that the loop form is departed from in those lamps, and that the carbon filament is merely bent to form an arch between the two platinum conductors. This departure is necessary in those low-power lamps, for the long thin filaments employed in the larger lamps would offer too much resistance, and consequently demand too much battery-power to raise them to a glowing or incandescent condition. The arch is therefore shortened, with the result of a lower candle-power, requiring a lower current. It will be seen, however, from the following table, that the candle-power of a lamp has a close relation to the battery-power required to work it :—

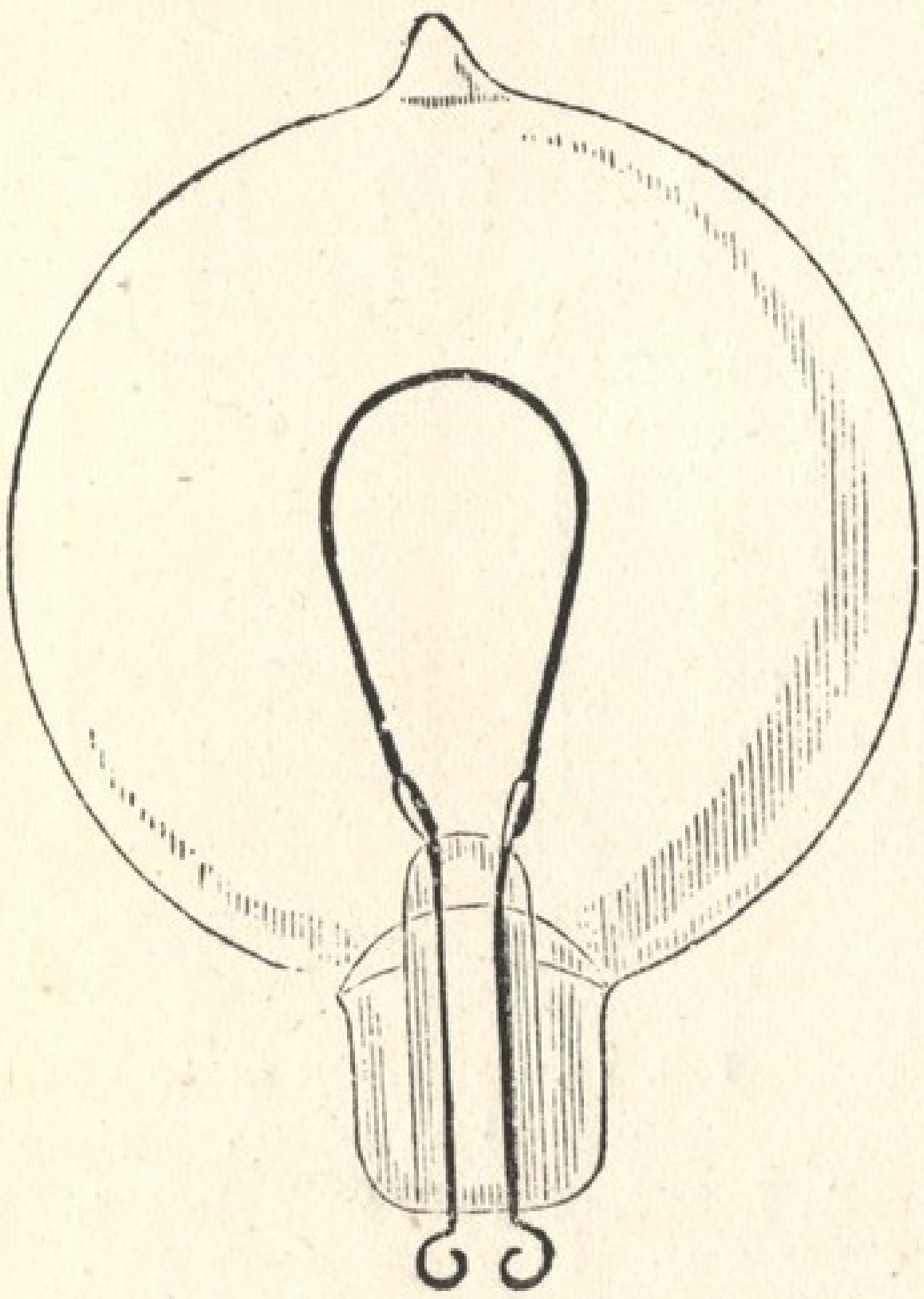


FIG. 8.—SWAN LOW-POWER LAMP.

Shortening of arch necessary.

SWAN'S INCANDESCENT ELECTRIC LAMPS.

VOLTAGE OF LAMP.	AMPÈRE OF CURRENT.	CANDLE-POWER OF LAMP.	CELLS OF BICHROMATE BATTERY.	WORKING LIFE OF LAMP.
8	1·9	2½	5	In properly treated, the lamps will last from 500 to 800 hours in constant use, and have been known to work for 1000 hours.
12	1·5	5	7	
15	2·3	10	9	
25	2·2	16	14	

In using a number of lamps, we require, of course, a larger

Number of cells for working two or more lamps.

battery of cells, but it is not necessary to increase the number of cells in multiples of the number required to work one lamp; for instance, although it may take five Bunsen cells in series to light up the $2\frac{1}{2}$-candle-power lamp, we shall be able to light up two such lamps from the same number of cells if these are larger, because the larger cells have less internal resistance than the small ones, and give, in consequence, a larger volume of current; but a battery soon becomes exhausted if the current taken from it exceeds 3 ampères.

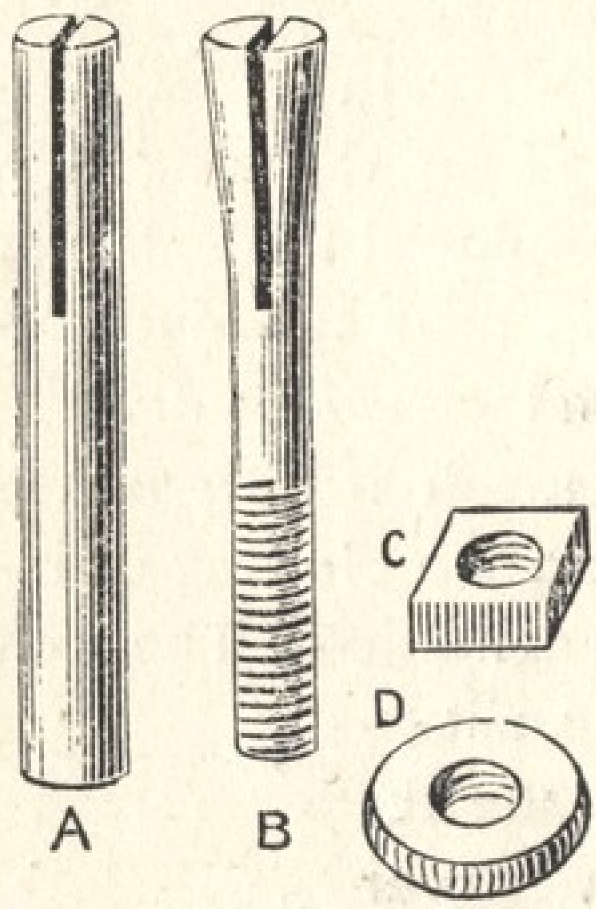


FIG. 10.—FITTINGS OF HOLDER FOR LAMP.

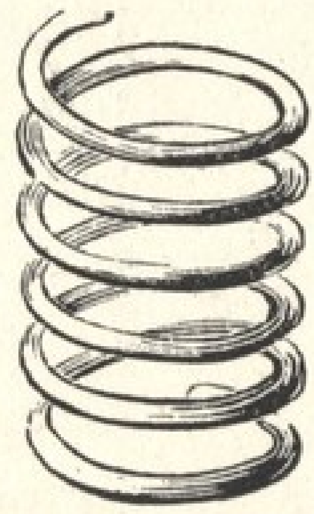


FIG. 9.—COIL OF BRASS WIRE USED TO SUPPORT LAMP ON STAND.

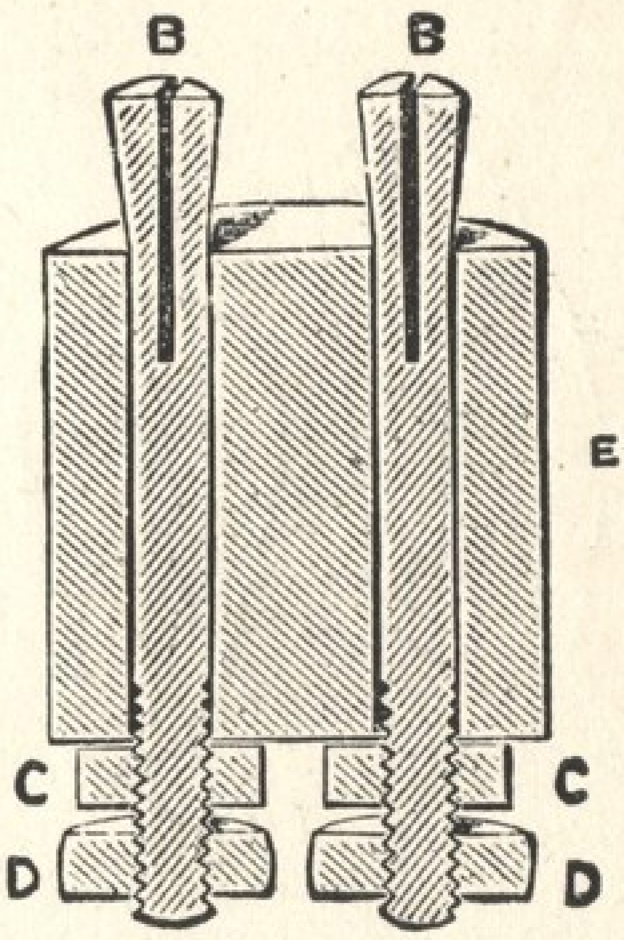


FIG. 11.—SECTION OF HOLDER FOR LAMP.

References to Letters in Figs. 10 and 11:—A, Length of Brass Wire Slotted. B, Brass Clip Finished. C, Upper Brass Nut. D, Lower Brass Nut, Milled Edge. E, Holder in Section.

Battery for three lamps.

If it is intended to work three lamps from one battery, the cells of that battery should be of larger dimensions than those employed to light up one or two lamps, and when three of the high resistance lamps are to be used for a period of from two to four hours, the battery-cells should not be less than half-gallon capacity.

Bichromate battery for small lamps.

The ordinary single fluid bichromate battery may be used with the small lamps, and give good results for two or three hours; but I feel myself bound to point out that the amateur electrician will only meet with disappointment if he looks for more than this. Rough carbon blocks may be used in the Bunsen battery for small lamps. The full current

of a large bichromate, or of a Bunsen battery, should not be sent at once through a lamp, but the carbon should be tempered by raising it to redness with a small number of cells, adding more cells in series until the required brilliancy of light has been obtained.

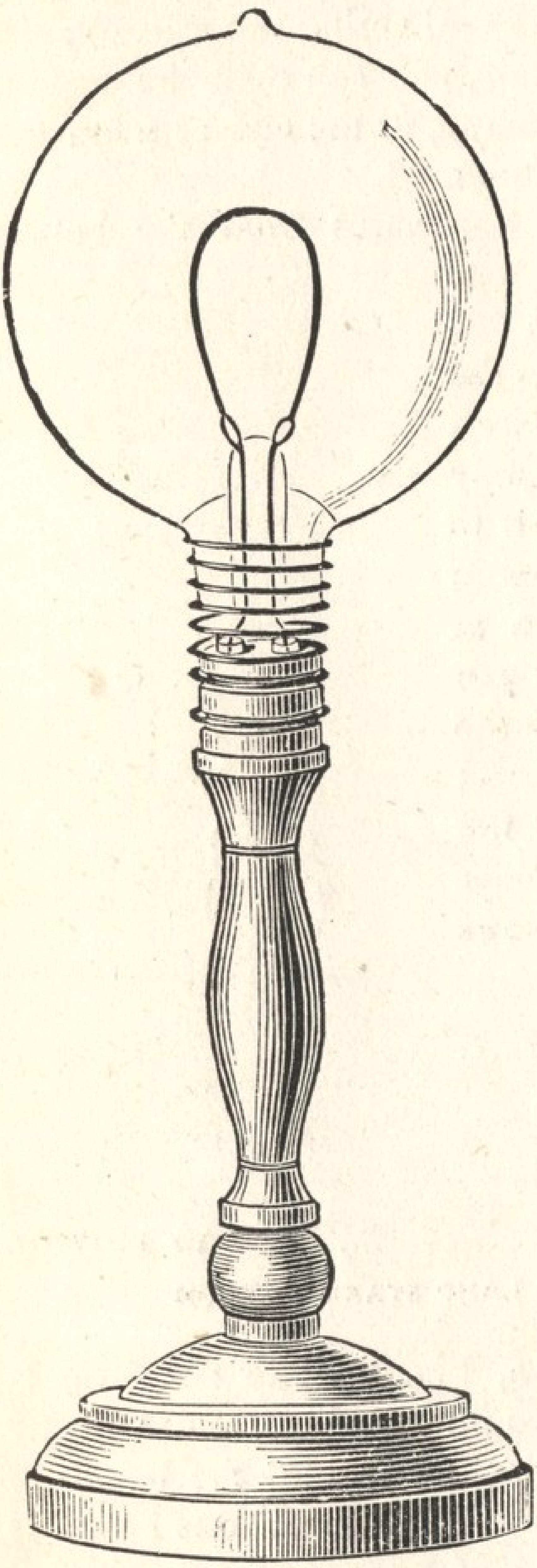


FIG. 13.—LAMP STAND AND SWAN LAMP, ELEVATION.

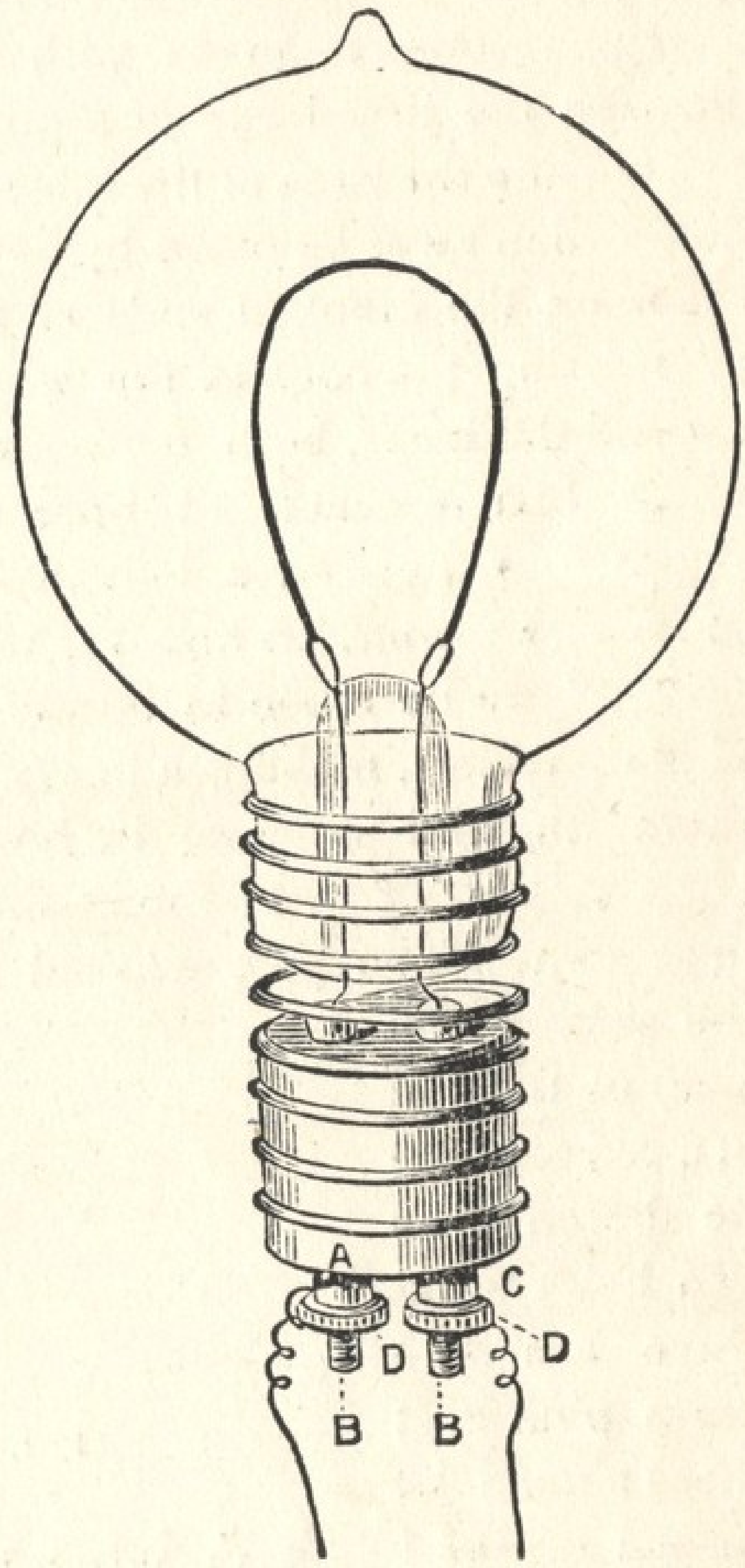


FIG. 12.—LAMP HOLDER ATTACHED TO LAMP, SHOWING HOW TO CONNECT THE PARTS.

Prices of lamps.

Regarding the price of the lamps these were offered by the makers at 5s. each lamp, but the price charged by vendors for all sizes, when one or two alone were purchased, was from 6s. to 6s. 6d.; but the prices of

incandescent lamps have been reduced to 1s. 9d. for the Edison-Swan lamp, and 1s. 6d. for lamps of other makers.

Coil for support of Swan lamp.

Vendors of the Swan lamps also sell a holder made of hard brass wire coiled into a spiral spring (see Fig. 9); this grips the neck of the lamp, and can easily be made to grip the top of a lamp-stand, or the end of a bracket. The price of this holder is from 1s. to 1s. 6d.

Connection is made with the line wires from the battery through the tiny loops of platinum wire left outside the neck of the lamp, and this connection must be made by hooking the loops on the crooked ends of the wires, or twisting the ends of the wires tightly around the loops, both methods likely to make bad contact. I have therefore devised a holder, shown at Figs. 10 and 11, which can be made to tightly grip the platinum wires, making a perfect contact therewith, and assisting in holding the lamp steady. Fig. 11 shows this holder in section. The part marked E shows the section (full size) of the end of a rod of ebonite bored with two holes to receive the two brass pins B,B; these should be turned out of tough $\frac{3}{16}$ brass wire A, Fig. 10, into the form B, screwed at one end to receive the two nuts C and D, and a gently tapering head made at the other end, slit one-third the length of the pin with a hacksaw or a slitting file. The use of this holder is shown at Fig. 12, where the slit heads of B,B, are shown gripping the platinum wires of the lamp, the two nuts C,C, are then tightened until good contact is made. The bared ends of the line wires are then wound once around each pin, and the nuts D,D, secure good contact here; the wire holder entwines the whole, keeping all

Suitable holder for lamp.

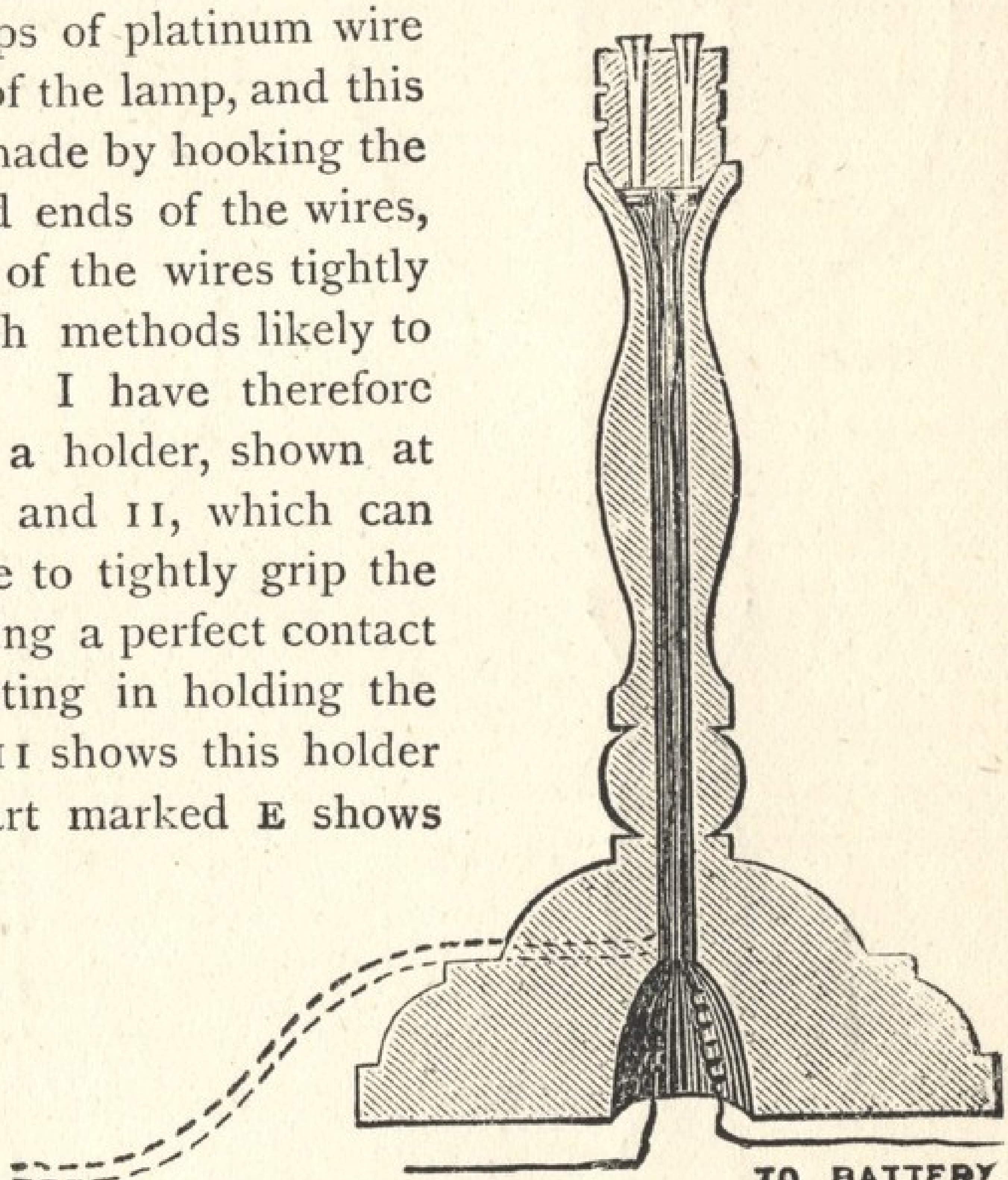


FIG. 14.—LAMP STAND SECTION.

steady. I may mention here that the above design was submitted to the Swan Electric Light Company, and that they claimed it as being covered by their patents for lamp-holders.

Stand for lamp.

The lamps may be supported on any kind of stand—a candlestick or a lamp-stand—or suspended from or attached to a bracket. The holder shown above will effectually insulate the two pins, and insulated wires must be used to lead up to the pins; care must be taken in using metal stands and brackets, that no part of the bare conducting wires or pins touch the metal of the stands. To meet the wants of those readers who may wish to make their own lamp-stands for a table lamp, I herewith give a design of one that may be turned out of wood. Fig. 13 shows the Swan lamp and holder (Fig. 12) mounted on the stand; and Fig. 14 is a sectional sketch of the stand and holder, showing a channel for the line wires through the neck of the stand. These may be separate wires or in the form of flexible silk cord, or braid, containing the two wires, this is sold in any colour, at from 6d. to 9d. per yard. Although the wires are shown as passing down through the base of the stand, and from thence branching off to the battery, it must be understood that this arrangement is only suitable for a fixed lamp, when the wires would be passed through a hole in the table or desk, for a portable lamp it will be best to make a hole through the upper part of the base, just large enough to pass the flexible cord through, as shown by dotted lines in sketch.

Design for wooden lamp-stand.

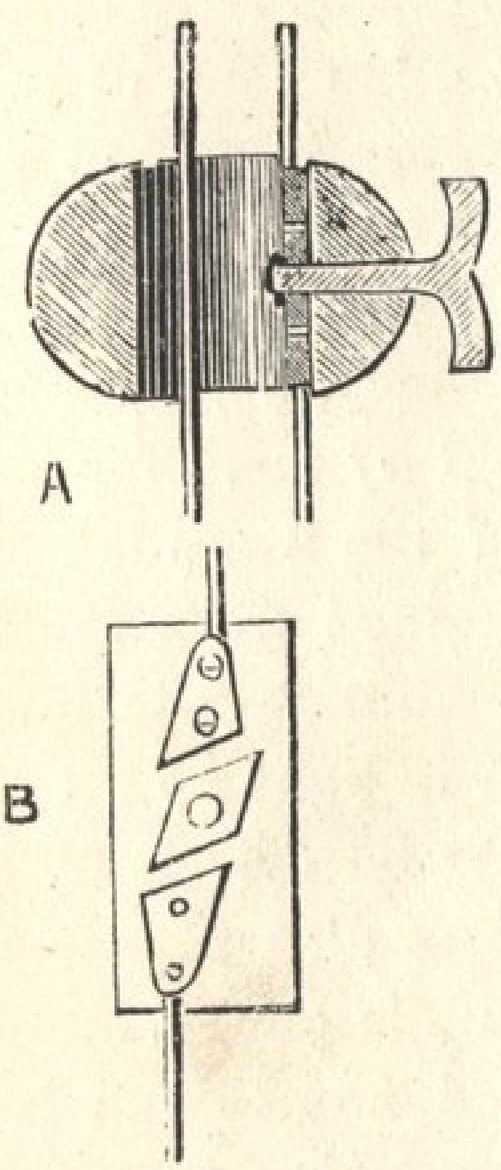


FIG. 15.—SWITCH.

A, Section of Switch in Position. B, Plan of End of Switch, showing contact-pieces attached to line wire.

Arrangement suitable for fixed lamp.

Regulation of intensity of light.

Under the usual arrangements for conducting the current from battery to lamp, there is no provision made for regulating the intensity of the light. We cannot turn on a feeble amount of current and get a small light, or a full current and produce a full light, as we turn gas on and off with a tap near the burner. Arrangements can be made for doing this

if desired, by interposing an inferior conductor in the circuit or a set of such conductors, technically termed resistances, but the usual method adopted by amateurs is to add a cell to the battery when the light is dull, or take off a cell when the light is too bright, or increase or diminish the strength of the battery solution to meet the requirements. Some makers of electric lamps provide a tap beneath the neck of each lamp, similar in form to those with which we are familar as applied to gas burners. This tap is merely the pivot of a switch which serves to make contact between two parts of the line, and may be introduced in the lamp-stand if desired, or fixed to any other part of the circuit. A form of switch suitable for this purpose is shown at Fig. 15, A and B. The actual contact surfaces of such switches should be guarded with strips of platinum foil soldered on.

Tap as pivot of switch.

Mr. Bottone, Wellington, Surrey, and Mr. Bonney, 25, Avenue Road, Lewisham, have issued a list of articles sold by them for the production of Domestic Electric Lights. Any of the Swan lamps and the batteries to work the lamps may be obtained from these dealers, and they also supply a dynamo-electric machine for amateurs. This machine will light up six of the Swan 10-candle lamps, and may be driven by a small engine or water-motor. The same dealers also supply a small machine capable of lighting a 15-volt 5-candle-power lamp for 15s.; and castings for this and similar small dynamos can be supplied from 5s. upwards, according to size of machine and the finish required on the castings. Chromic acid is preferable to bichromate of potash as a depolariser in small batteries. It is used in the proportion of 3 oz. chromic and 3 oz. sulphuric acid in each pint of water, and should be contained in glass cells. The zinc and carbon should be lifted out of the solution when not in use.

Dynamo-electric machine for amateurs.

CHAPTER III.

A NEW ELECTRIC LIGHT BATTERY.

Difficulty in maintaining current with Grove and Bunsen batteries—Dale's "Patent Granule Battery"—Edwinson's battery—Making up of Dale's battery—Porous cell and its packing—Charge for porous cell—Treatment of zinc cylinder—Prices of batteries in different forms—Advantages of battery—Chloride of zinc: how made—Casting lead heads on carbons—Prices of cells, etc.—Lamps suitable for primary battery—Number of cells required for electric lighting—Simple lamp for amateurs—Hints on making this lamp.

IN the preceding chapters I pointed out the inconvenience of maintaining an efficient current for electric lamps from voltaic batteries, because there was no generator suitable to the purpose excepting those noisome nitric acid batteries invented by Professors Grove and Bunsen. I also mentioned some forms of batteries in which bichromate of potash was used instead of nitric acid, but nearly all such batteries are open to the objection of inconstancy, unless the bichromate solution is kept in a continual state of agitation, and this necessitates a form of cell too troublesome and expensive to the amateur. At that time I heard of a new battery brought out by Mr. Dale, now of 10, *Cursitor St., London, E.C.*, and I supposed it to be one identical with a battery of my own invention, but I had not then the opportunity of investigating its identity. Since then, however, Mr. Dale has been kind enough to give me the opportunity, and I have much pleasure in laying the result before my readers.

Difficulty in maintaining current with Grove and Bunsen batteries.

It is well known that the inconstancy of bichromate of potash batteries is caused by a film of hydrogen being deposited on the carbon plates, and thus causing a condition of things in the cell which is described by the term "polarization." Now, if we can get this film off as

Dale's "Patent Granule Battery."

rapidly as it is formed, or if we can get the carbon to throw it off, we shall secure the cell from being polarized. The first object is attained by heating or agitating the liquid, but Mr. Dale conceived that the second would be best, and could be obtained by exposing a very large surface of carbon to the bichromate of potash solution, and to have that surface broken up into innumerable small points instead of presenting a plane surface to the liquid. This can be secured by packing a quantity of broken carbon around the carbon plate in the outer or larger battery cell.

Whilst he was experimenting in this direction, my brother and myself were endeavouring to attain the same end by immersing a large number of small strips of carbon, instead of one large plate, in the outer solution, and by this means made a most powerful battery, free from the evil of rapid polarization. We used the solutions prescribed by Mr. Dale for his chloride battery, a battery made up for the purpose of supplying a current to electric bells doing heavy work. We experienced some little difficulty with the zinc bolts used in this form of battery, and decided to abandon them in favour of zinc cylinders, made to order by Mr. Dale; this gentleman also adopted cylinders of zinc instead of zinc rods. Our form of battery, therefore, differed from his only in one or two particulars, readily perceptible to my readers.

Edwinson's battery.

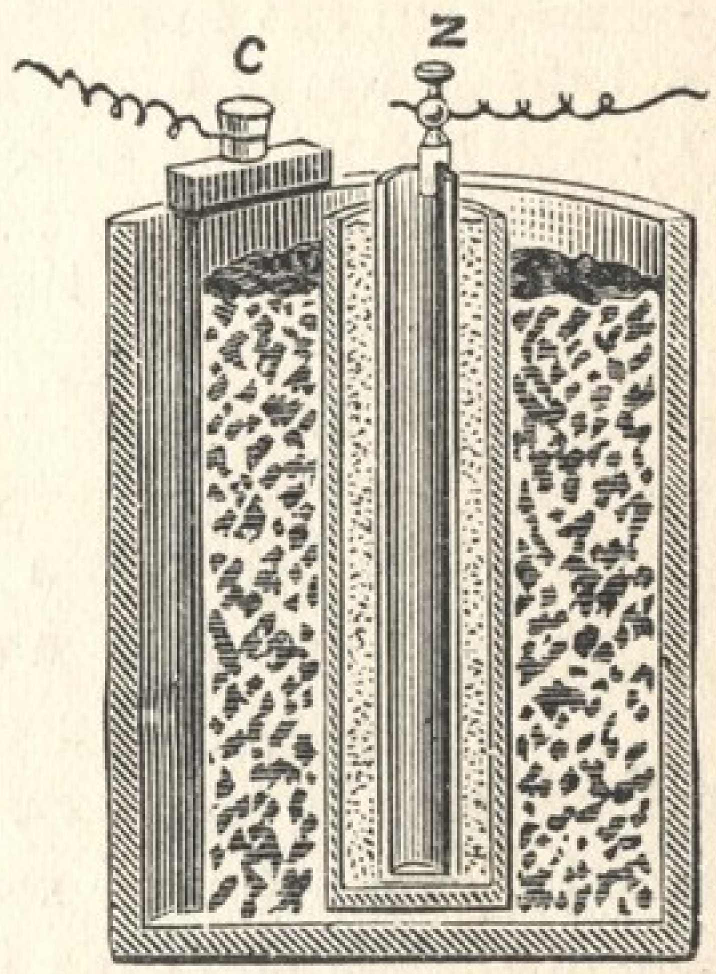


FIG. 16. — DALE'S PATENT GRANULE BATTERY.

Section of cell showing internal arrangement. C, carbon; Z, zinc.

Dale's Patent "Granule" Battery, now not to be obtained, was made up as follows:—An outer stoneware battery cell of any convenient size to suit the requirements of the work in hand; a cell of porous earthenware to go inside the above-mentioned cell; a cylinder of zinc to go into the porous cell; and a strip of carbon to go into the outer stoneware cell; the whole as shown in sketch. This cell is thus charged:—The porous cell (which should be rather larger in diameter than the usual cells of this class, and made of the best close-grained

Making up of Dale's battery.

Porous cell and its packing.

white ware) must be placed in the centre of the stoneware cell, and packed in this position with a number of fragments of gas carbon, broken to the size of beans ; these fragments must also hold a strip of gas carbon, such as the strips used in the Léclanché cells, to form a convenient terminal to the negative element. When the space between the sides of the two cells has been thus filled up with broken carbon, there will still be room for a quantity of liquid between the lumps of carbon, and this space is filled with a mixture of a saturated solution of bichromate of potash, 2 parts, and common muriatic acid, 1 part. The charge for the inner or porous cell, in which the zinc cylinder forms the positive element, is a solution of chloride of zinc in water, in the proportion of solid zinc chloride, $\frac{3}{4}$ oz., to 1 pint of water. The zinc cylinder should be well amalgamated with mercury before being put into the cell, and it will also be advisable to pour from $\frac{1}{2}$ oz. to 1 oz. of mercury (quicksilver) into each cell with the zinc. A saturated solution of bichromate of potash means that this salt must be dissolved in warm water until the water will dissolve no more, this quantity being generally in the proportion of 3 of the salt to 1 pint of water. Care must be taken not to spill the solution on boards, carpet, or clothes, as it will leave an indelible stain ; and it should also be known that the salt or its solution is very poisonous. Bichromate of potash, 1s. to 1s. 2d. per lb. ; Chloride of zinc, 1s. 6d. per lb.; Muriatic acid, 4d. per lb.; Mercury, about 3s. 6d. per lb.; Carbon, 6d. per lb.

Charge for porous cell.

Treatment of zinc cylinder.

The prices of Dale's Patent Granule Battery, per cell, complete were as follows, according to size :—

Prices of batteries in different forms.

						s.	d.
A.	Square	Porcelain	Cell,	5 in. by 3 in. by $1\frac{3}{4}$ in.,	each cell,	4	6
B.	,,	,,	,,	6 in. by 4 in. by $2\frac{1}{4}$ in.,	,,	5	6
C.	,,	Stoneware	,,	$6\frac{1}{4}$ in. by $4\frac{1}{4}$ in. by $2\frac{1}{4}$ in.,	,,	5	6
D.	,,	,,	,,	7 in. by 5 in. by 3 in.,	,,	6	6
H.	Round	,,	,,	$6\frac{1}{2}$ in. by 5 in. in diameter	,,	5	6
K.	,,	,,	,,	$6\frac{1}{2}$ in. by 5 in. ,,	,,	4	6
L.	,,	,,	,,	8 in. by 5 in. ,,	,,	6	6
M.		,,	,,	10 in. by 6 in. ,,	,,	7	6

The series from A to H are supplied sealed with pitch, to prevent spilling of the liquid whilst being carried, and are used for

firing fuses, testing wires, and working medical coils. The series from K to M are left open at the top, and the two latter sizes have an aperture at the bottom to facilitate the drawing-off spent solution when the cells need recharging.

The advantages of this battery over others is as follows:—Compared with the Bunsen cell of equal size, its force (E.M.F.) is only $\frac{4}{100}$ of a volt less. It is free from noisome fumes. When charged and set up, it will remain ready for action at any time within a week. It will work intermittingly or constantly, as may be required: can be worked in spells of three hours each for five or six successive days without attention, or do two or three days' work of seven hours each without requiring to be recharged. Five cells of the L size will keep a five-candle incandescent electric lamp lighted up for three hours each evening throughout one week, or perhaps longer, without requiring to be recharged; and one battery of my own form has been in use for six days at such work as coppering or nickel-plating before it gave signs of failure. In my own form of battery I suspend a number of carbon strips from a cover surrounding the porous cell; this cover is perforated with holes, to admit the strips, and these may be of roughly cut carbon; in fact, rough, jagged, angular strips are best for this purpose. Each strip must have a head of lead cast on to it; one of those heads should be fitted with a brass terminal or binding screw, and all the strips must be connected together by a strip or ring of lead. I also make my own chloride of zinc by dissolving scrap zinc in muriatic acid until the acid will dissolve no more, and then diluting the liquid with twice its bulk of rain water. Sal-ammoniac (from two to three ounces) may also be used in the porous cell instead of chloride of zinc.

Advantages of battery.

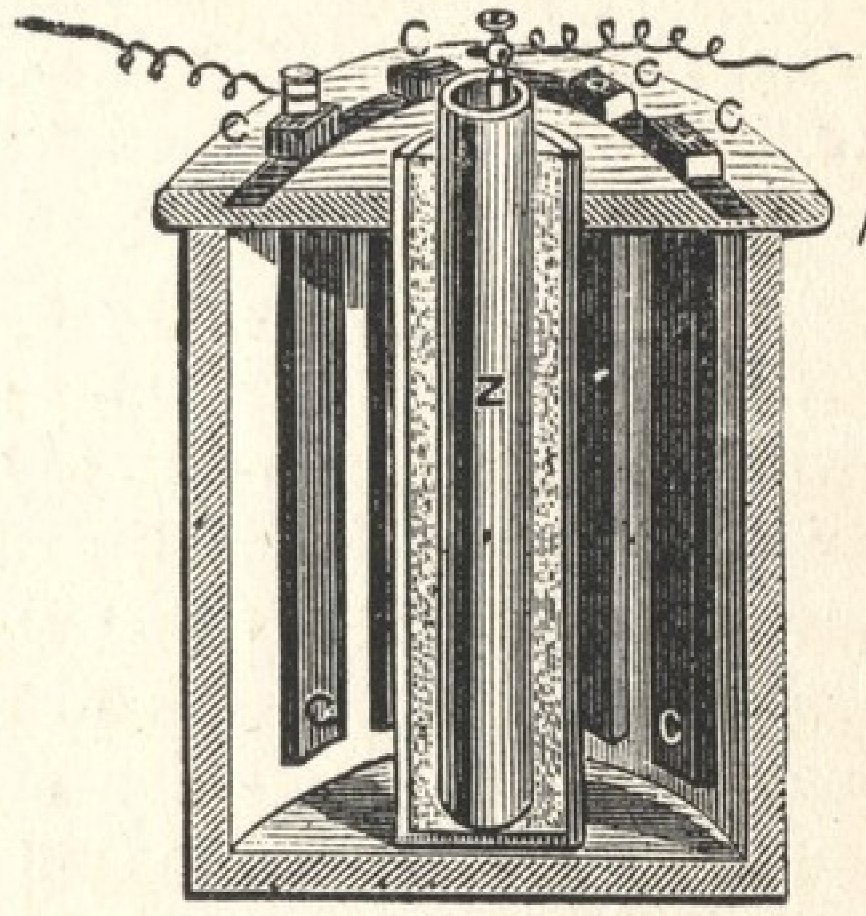


FIG. 17.—IMPROVED BICHROMATE OF POTASH AND CHLORIDE OF ZINC BATTERY.

Section of cell showing internal arrangement; C, C, C, strips of carbon; L, L, strips of lead to maintain contact between carbons; A, cover of wood suspending carbon strips; Z, zinc cylinder.

Chloride of zinc: how made.

Before casting the lead heads on the carbons, these must be prepared with hot paraffin wax. Melt the wax well into the head of the carbon strip to the depth of one inch, driving it in with a hot iron. In casting the lead head it will be observed that the hot lead will drive out and burn excess of paraffin, but enough will be left to prevent the bichromate salt from creeping up under the head. If the carbons can be cast in a ring of lead it will be an advantage to do so ; the next best method is that of attaching a strip of lead by autogenous soldering ; ordinary solder gets "eaten away" in the course of a few months, whilst copper and brass wires soldered to the heads soon disappear.

Casting lead heads on carbons.

Mr. Dale then supplied suitable cells and parts for them at the undermentioned prices :—Stoneware cells, 10d. each ; stoneware cells, L and M size, 2s. and 2s. 9d. Porous cells for the 6 in. high batteries, 6d. each ; for the larger sizes, 9d. and 10d. each. Zinc cylinders to fit porous cells, to order, 1s. per lb. ; or amalgamated, ready for working, 1s. 3d. per lb. The prices of suitable cylinders are—for K, 1s. 3d. ; L, 1s. 9d. ; M, 2s. 3d. ; these prices include cost of brass terminals to each cylinder. Suitable carbons, with lead cap and terminal—for K, 1s. ; L, 1s. 9d.; M, 2s. 8d. Rough thin strips of carbon, without lead heads, 3d. to 4d. each. I may also mention that the maker does not fear any damage to his patent rights from amateurs imitating my form of the battery, and will be most happy to supply them with materials, or advise them in the use thereof.

Prices of cells, etc.

The lamps most suitable to be worked by the current from this battery are the incandescent lamps of low resistance, giving a light of about 5-candle power each lamp. Lamps of comparatively low resistance should always be selected to use with primary batteries, provided the resistance is not so low as to require more than 3 ampères of current to light the lamps. I have already given a table showing the lamps most suitable for use with a certain number of cells. If, however, lamps of a higher voltage are selected by the amateur electrician, he must of necessity increase the number of cells in the ratio of two Bunsen's cells to each rise of 3 volts required, or one single fluid bichromate to each rise of 2 volts. Thus, to get a 10-candle-power light from a 15-volt 10-candle-power lamp, fully ten of

Lamps suitable for primary battery.

those cells in series will be required, and, as the resistance of lamp, wires, and connections may be even higher than the force of ten cells will overcome, we shall probably require eleven or twelve cells in series to properly light up the carbon filament. If we put on more lamps we must put on more cells in parallel circuit, and must bear in mind that enough cells in series must be employed to get up the proper glow. Even when the lamp is doing its best it may not give the light of its nominal candle power as compared with that of good sperm candles. It will be well to know that incandescent lamps should never be subjected to enough current to give out a light with a pale blue or violet tint, as this indicates destruction of the carbon filament. They are working safely when they give a white glow, slightly tinged with yellow. The "granule" battery is not suitable to the maintenance of arc lights, nor to similar work demanding a large volume of current at high tension.

Number of cells required for electric lighting.

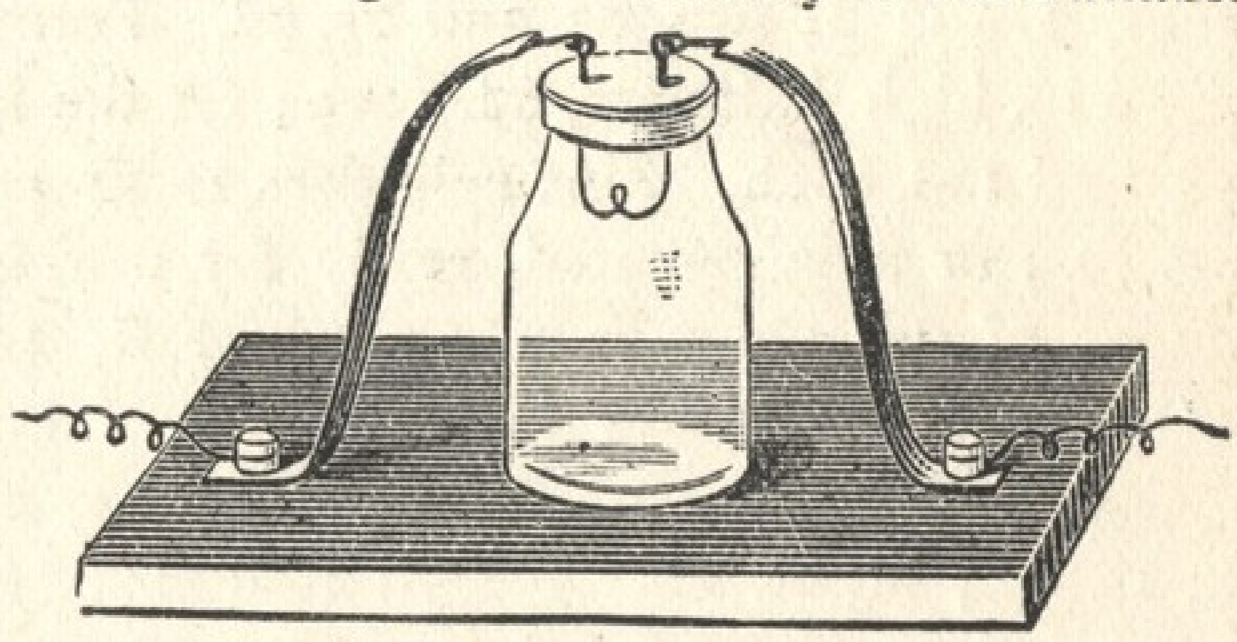


FIG. 18.—AMATEUR INCANDESCENT ELECTRIC LAMP.

Before I close this chapter, I may mention here a lamp shewn in Fig. 18, which any one may make of the following homely materials :—A wide-mouthed glass jar or pickle-bottle, into the mouth of which fits a bung or a circular disc of wood. Through this passes a bit of fine platinum wire ; this is made into a loop, in imitation of Swan's lamp carbon, and the other end is passed out through the bung or stopper again. Two straps of copper, or stout wires of this metal, are secured to a base board on each side of the jar by a pair of binding screws (telegraph pattern). These straps rise up by the side of the jar, the ends are bent over the top, and tightly clip or grip the two ends of the looped platinum wire. On connecting the wires from a ten-cell Bunsen battery to the binding screws of the lamp, the platinum loop gave out enough light to see to read a book by it comfortably. The ten cells of the battery were made up of gallipots, to save the expense of outer jars.

Simple lamp for amateurs.

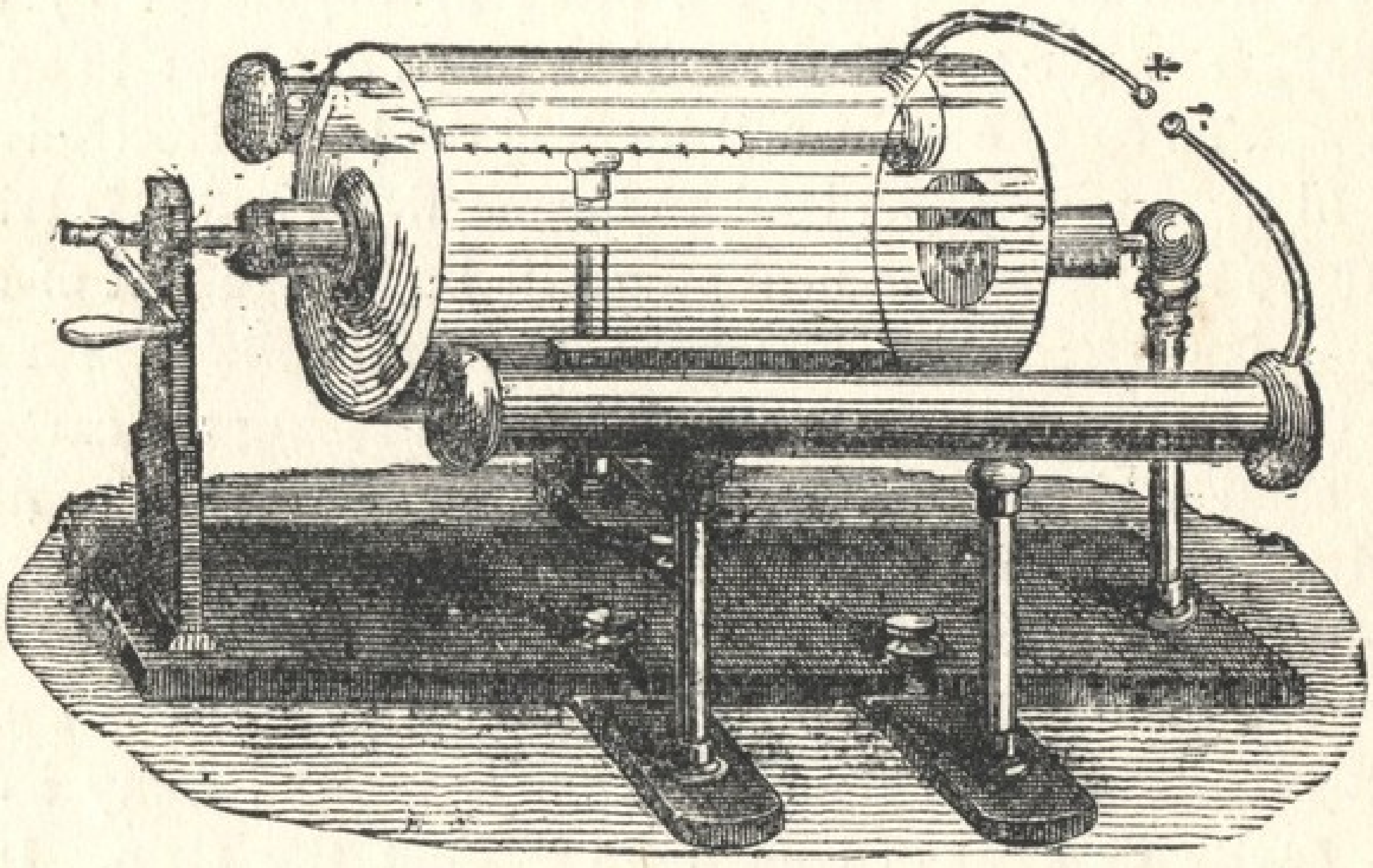
Readers who may wish to imitate this lamp will please under-

stand that a white glass jar should be used, not green glass. Copper strap will be better than copper wire—that is, a strip cut off from some sheet copper. The ends of the platinum wire may be tightly clipped by the turned-down ends of the copper strap pinched closely with a pair of pincers or pliers. To avoid disappointment, get more platinum than will be required for one experiment, for it is just possible that several lengths will be fused in the course of an evening's amusement.

Hints on making this lamp.

With regard to casting lead heads to strips of carbon, in order to resist the creeping action of the battery salt that will otherwise creep up and destroy the binding screw and its connections, I may say that there are two modes of preparing the plate—one by melting lead round the top of the carbon to imbed the binding screw in a head of lead, and the other by depositing by electric action copper on the top of the carbon plate, and thereto soldering the screw. To carry out the first method the home electrician must provide himself with some lead and some fine sand. Having obtained these requisites, the next step will be to see first of all that the carbon is perfectly dry, and then to fix the binding screw to it and stick it, head downwards, in the sand, pressing the carbon well into the sand until the upper edge has penetrated to the depth of ¾ inch below the surface. The sand, I should have said, should be placed in any convenient vessel, such as a shallow bowl or deep saucer, not much wider than the carbon strip, and the sand that surrounds the head must then be carefully cleared away so as to leave a cavity or kind of trench all around the strip. It is an operation which requires some nicety of manipulation on account of the want of cohesion in the sand, and therefore must be effected with care. The lead, which must be brought to melting-point in a ladle, and kept in this condition while the cavity round the plate is being prepared, must then be poured in so as to form the necessary head. The lead will quickly resume its original solid condition, and the strip with the lead head thus formed to it must then be lifted out of the sand. When taken out it will be rough in appearance, and perhaps somewhat out of shape, and the home electrician must proceed without a moment's delay to trim it into shape by the aid of an old knife and a rasp file, in order to coat the head with Brunswick black before it is quite cold. As this mode,

perhaps, will be easier carried out by the amateur than forming a head of copper by electro deposition, I will content myself with bringing under the reader's notice this comparatively easy method of attaining the end in view.



CYLINDRICAL ELECTRICAL MACHINE.
(*See page* 77.)

PART III.

MAGNETO-ELECTRIC MACHINES AND MACHINERY.

MAGNETO-ELECTRIC MACHINES AND MACHINERY.

CHAPTER I.

MAGNETO-ELECTRIC MACHINE FOR MEDICAL PURPOSES.

Introductory — Distinction between magneto-electric and dynamo-electric machines — First principles of magneto-electric machinery — Inductive influence and induced currents—Utilisation of magnetic influence—Parts and construction of machine and magnet—Bobbins and their parts—Cores —Mode of mounting bobbins—Disposal of ends of wires—Tube and projecting spindles—Contact spindle and plug—Insulation of spindle—Course of electric current—Economisation of current—Steel contact spring—Short circuiting coils—Construction of frame—Supports of frame in box—Handle and driving spindle—Taking off current—Regulation of current and shocks—Armature: its uses and how to fit it—Dale's magneto-electric machines—Gent and Co.'s electric machines and pamphlet—Application of current for medical purposes.

Introductory

IN taking up the description of magneto-electric machines and machinery, I had intended to proceed from the construction of a simple useful machine up to the details of more complicated and larger machines. This, however, space prevents me from doing, and I can only show the curious in these matters how they may make such a machine as that which is described in detail in this chapter, and illustrated in the sketches accompanying it. There is but little difference in principle between any of the forms of machines used in the generation of dynamic electricity, since all depend upon the movements of magnets in front of or close to their armatures, or, conversely, the movement of armatures in front of magnets, to generate an electric current. When permanent magnets are used in their construction the machines are termed magneto-electric machines; when electro-magnets or their armatures are made to move in each other

vicinity, and so create electric currents, the machines are termed dynamo-electric machines, because for distinction the current is supposed to be generated by the motive power imparted to the machine. But, as a matter of fact, there are few machines made that could be strictly named dynamo-electric machines, if indeed there are any that will merit the definition, since all depend on

Distinction between magneto-electric and dynamo-electric machines.

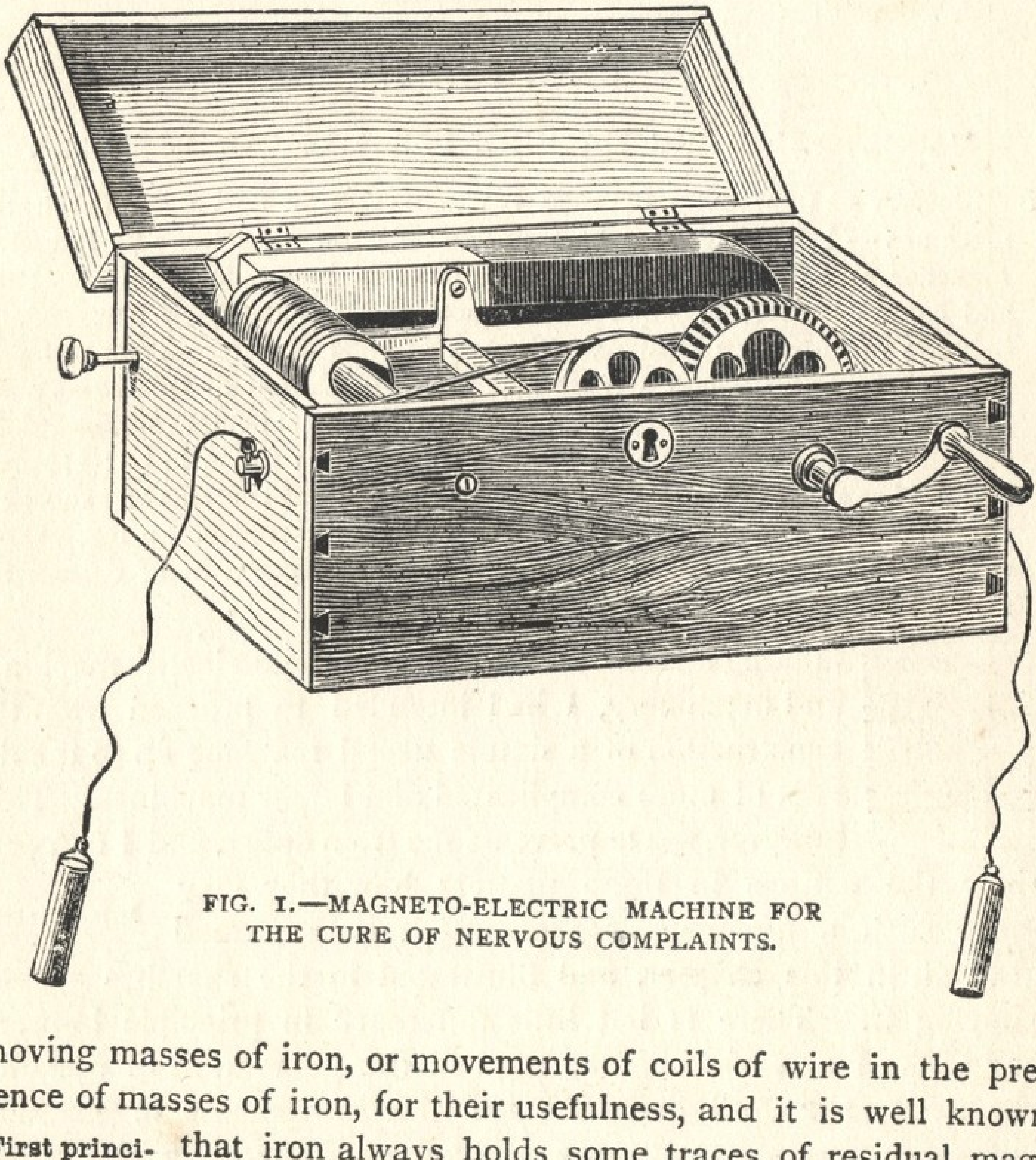
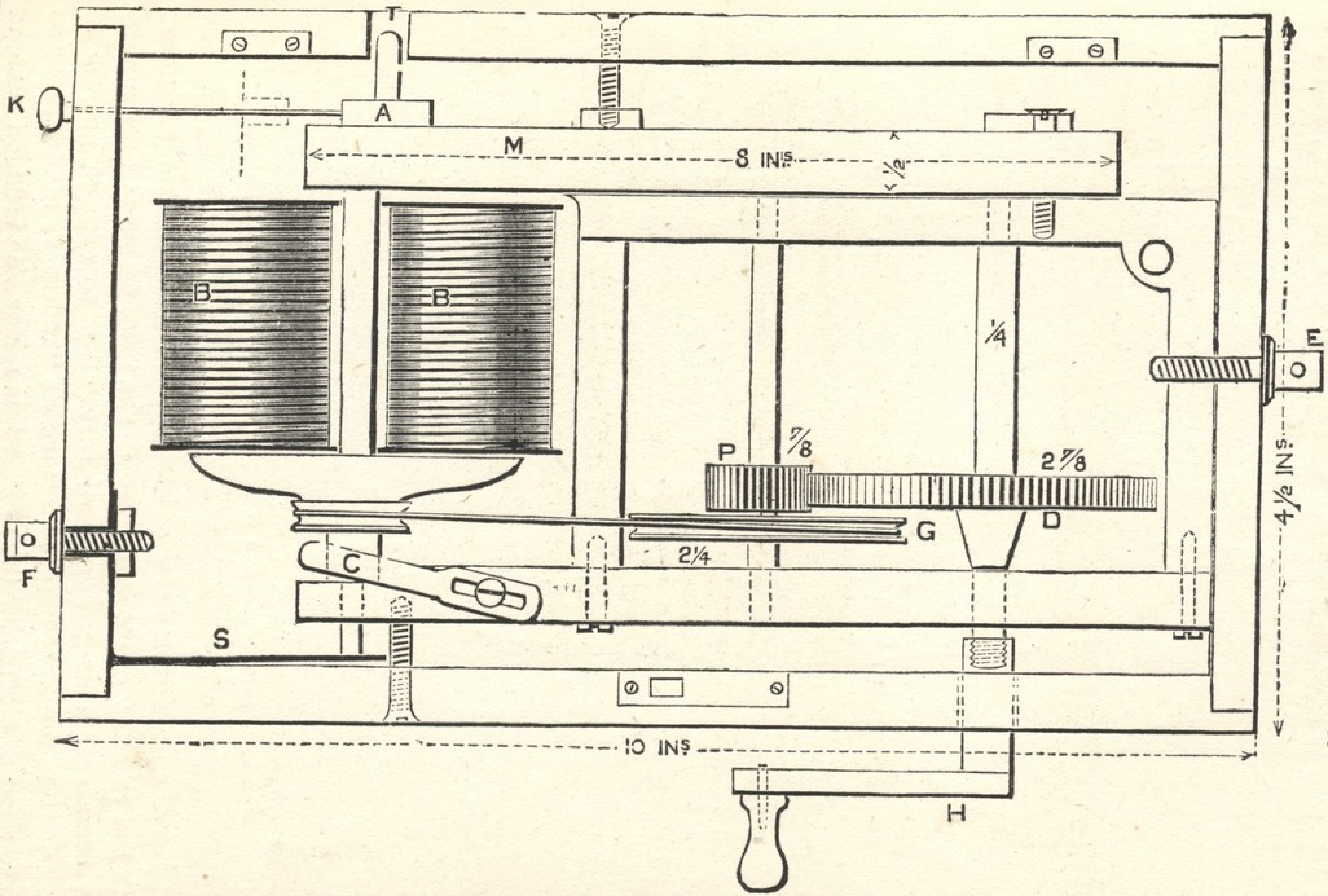


FIG. I.—MAGNETO-ELECTRIC MACHINE FOR THE CURE OF NERVOUS COMPLAINTS.

moving masses of iron, or movements of coils of wire in the presence of masses of iron, for their usefulness, and it is well known that iron always holds some traces of residual magnetism. Without stopping to quote how or by whom the property was discovered and applied, I will say at once that it is well known,. that when a piece of iron is made to move within the influence of a magnet, the magnet makes, as it

First principles of magneto-electric machinery.



REFERENCES TO LETTERS IN FIG. 2.

A, Armature.
B, Bobbins.
C, Contact Break.
D, Driving Wheel.
E, F, Studs to connect Shocking Handles.
G, Grooved Wheel.
H, Driving Handle.
K, Armature Knob.
M, Magnet.
S, Spring connecting F with spindle of coils.

FIG. 2.—PLAN OF MAGNETO ELECTRIC MACHINE IN BOX, SHOWING ALL ITS PARTS IN THEIR RELATIVE POSITIONS.

Inductive influence and induced currents.

were a snatch at the iron as it passes to and fro, and if the piece of iron has been wound with insulated copper wire, it is known that an electrical impulse is sent through the wire at every snatch of the magnet. The force of this impulse is regulated by the strength of the magnet, and the

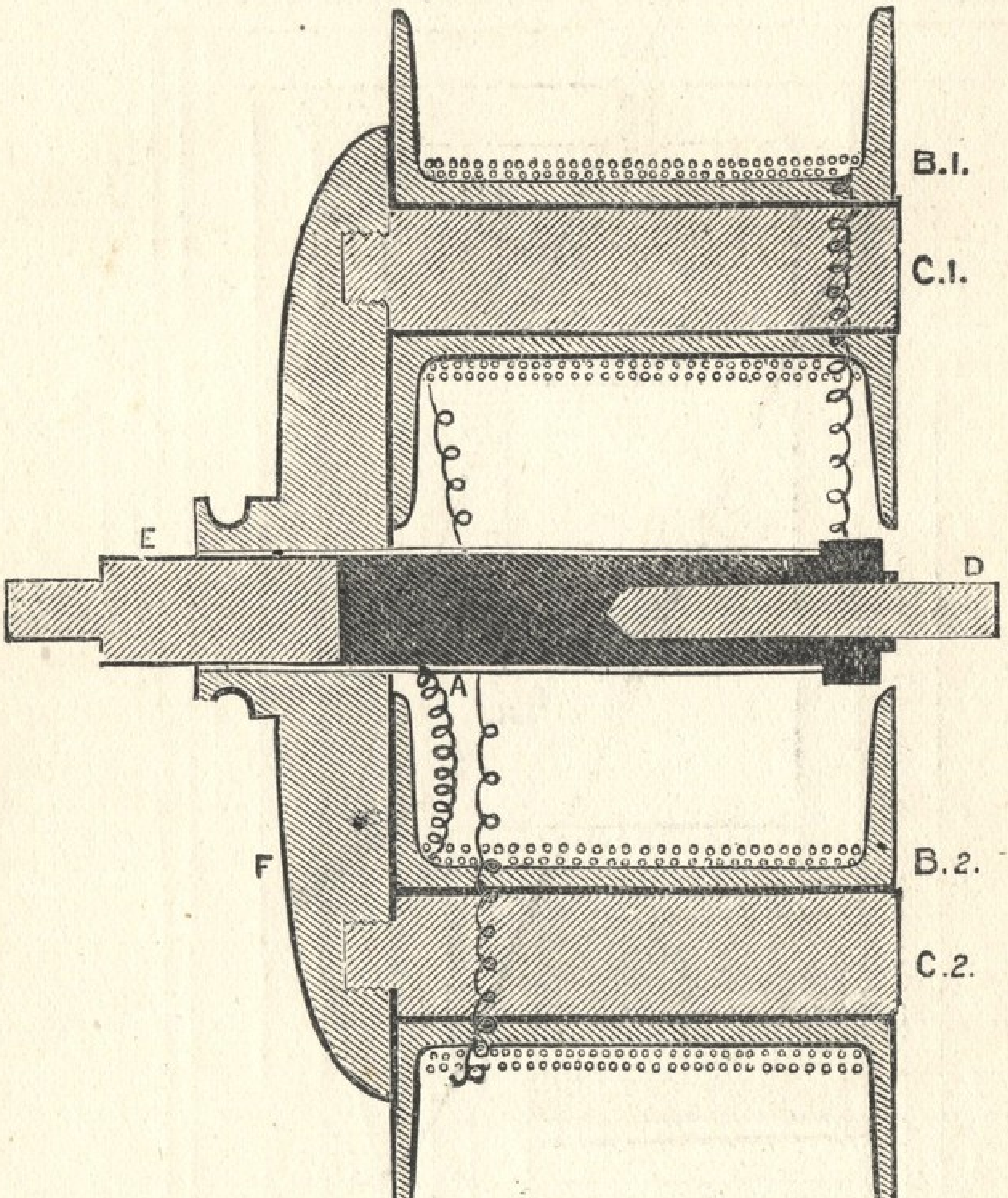


FIG. 3.—SECTION OF COIL BOBBINS, FULL SIZE. A, Brass Socket. B 1 & 2, Bobbins. C 1 & 2, Cores. D, Insulated Spindle. E, Contact Spindle. F, Core-holder.

number of convolutions of wire brought within its influence together with the rapidity of motion given to the iron, which is here named the armature. This property of magnetism to cause a current of electricity in a coil of wire, is termed its "inductive influence," and the current of electricity thus caused, is termed an induced current.

All currents of electricity possess this property, and exert an inductive influence on all conducting bodies contiguous to those which convey the currents.

We cannot stay now to inquire into the causes of induced

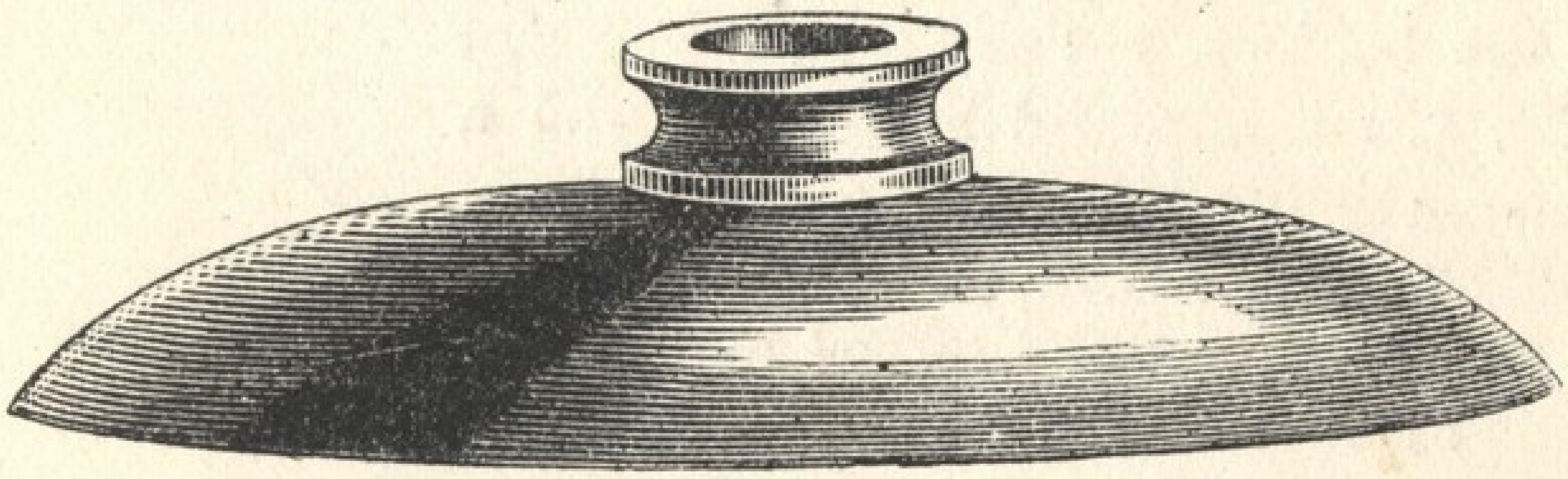


FIG. 4.—CORE-HOLDER. FULL SIZE.

currents, the laws which govern them, nor their general characteristics; suffice it to say that the well-known property of magnets to induce a current of electricity in a coil of wire wound on an armature moved within their influence, has been utilised in generating currents of sufficient intensity to flash through the muscles and nerves of human beings, and cause those peculiar sensations known as shocks. The magneto-electric machine now before us is therefore simply a shocking machine, and its use is to send a series of electrical tremors through the body in such a manner as to relieve pain, and assist in curing disease.

Utilisation of magnetic influence.

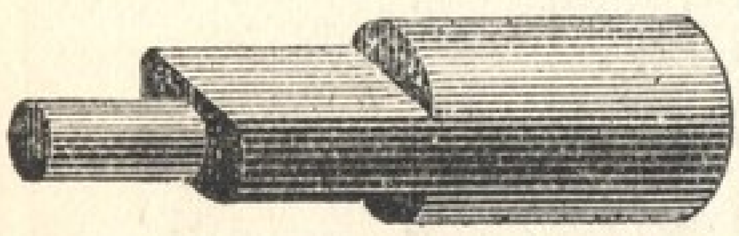


FIG. 5.—END OF CONTACT SPINDLE.

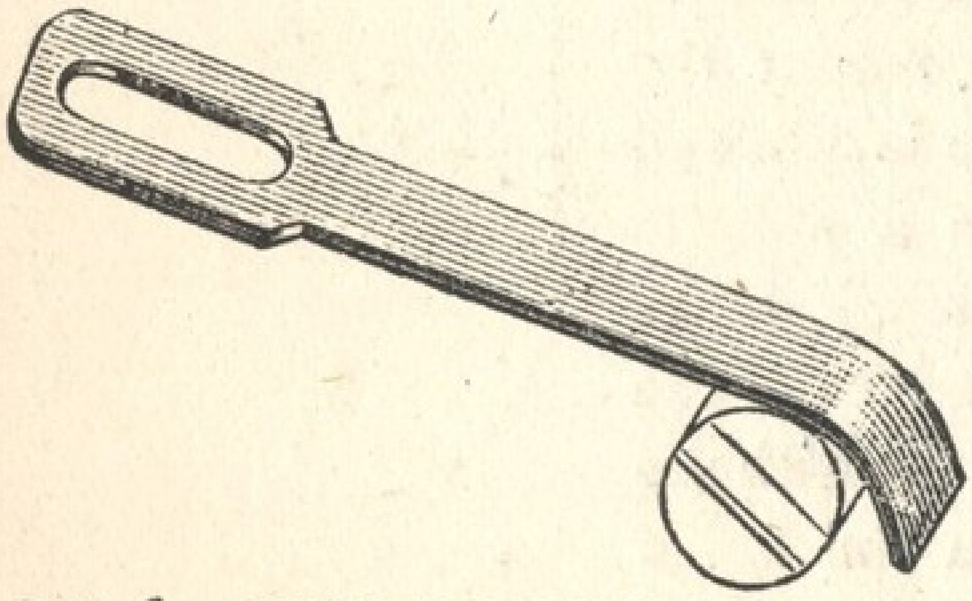


FIG. 6.—CONTACT SPRING OF BREAK.

The most simple form of such a machine is shown at Fig. 1, where the machine is represented as enclosed in a mahogany box, fitted with lock and key: and at Fig. 2, which is a plan of the same, exhibiting its construction and arrangement. The machine itself consists of a permanent magnet M, 8 inches long, with legs 1 inch wide by ½ inch thick; the price of such a magnet will be from 6s. to 6s. 6d., and is best when bought

Parts and construction of machine and magnet.

of makers or vendors, for an amateur cannot easily make one; nor can he get such good results from a home-made magnet. The next most important parts are the two bobbins, B B, shown in section and in detail at Figs. 3, 4, 5, and 6. These are made up of the core-holder (Fig. 4), and F in section (Fig. 3); the cores, C 1 and C 2; the bobbins, B 1 and B 2; the contact spindle, E, the insulated spindle, D, and a piece of brass tube, A. The core-holder is shown full size: it may be of cast iron, cast and turned to the form shown, or it may be made out of a piece of wrought iron of the form shown Fig. 8; in this case a driving pulley will have to be fitted on the contact spindle, and this firmly fixed in the core-holder. The cores are made out of best round iron $\frac{7}{16}$ inch in diameter, turned and screwed at one end and fitted into the core-holder, as shown. On these cores are fitted two bobbins of turned iron, $1\frac{5}{8}$ inch in diameter, with the outer faces filed or planed true with the ends of the cores; the inside parts of the flanges, and the bodies of the bobbins should be well covered with melted shellac, and then filled with No. 34 or 36 silk-covered copper wire regularly wound on. To do this, mount the bobbins inside end to inside end on a mandrel, or on a spindle secured in a lathe; small holes should have been bored near the edges of the inside flanges, and a small groove cut with the file for each of the flanges from the holes down to the body of each bobbin. The hole is to take the starting end of the wire, and the groove is to receive the wire; therefore pass 6 inches of the wire through one of the holes, secure it there with a drop of sealing-wax, lay the wire along the groove, then secure this also with a streak of sealing-wax; hold the wood bobbin (on which the wire is wound) on a piece of iron wire held in one hand, at the distance of

Bobbins and their parts.

Cores.

Mode of mounting bobbins.

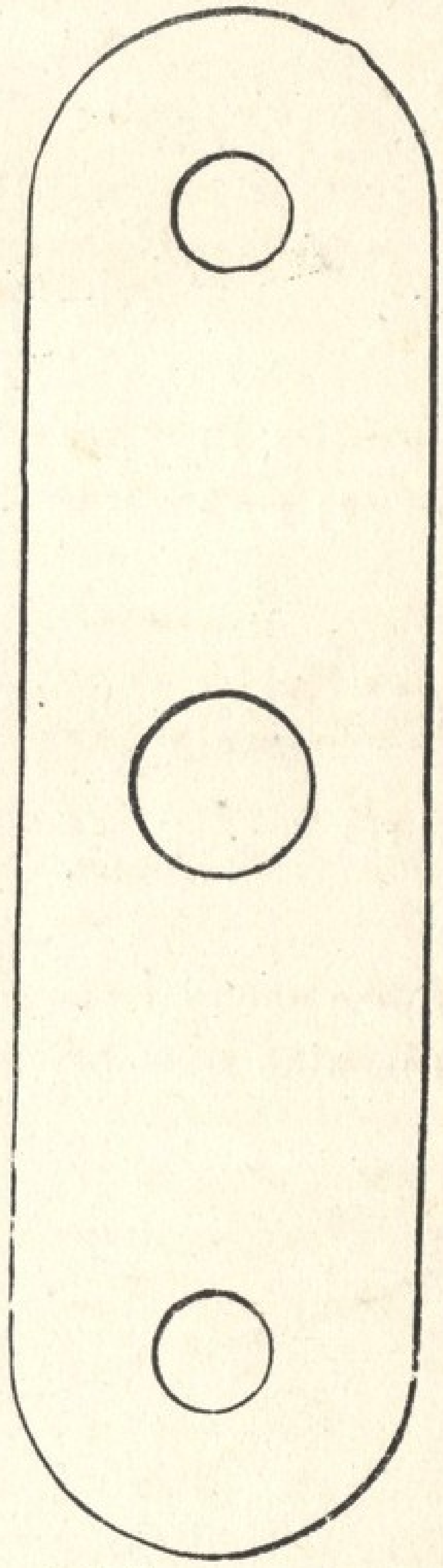


FIG. 8.—FORM OF WROUGHT-IRON CORE-HOLDER.

7 or 8 inches from the metal bobbin; start the lathe, and allow the wire to guide the hand to and fro instead of attempting to make the hand guide the wire. Work slowly and guide it on well, and when the first bobbin is full to within $\frac{1}{8}$ of an inch, fasten off the wire at one side with a bit of sealing-wax; cut off the wire, leaving 6 inches as at starting, and proceed to fill the other bobbin in the same way. When the bobbins are fitted on their cores, it will be seen that the wires from the inside ends will be similarly placed as those on the legs of an electric bell magnet; these two ends must be soldered together when the bobbins are in position on their cores. There now remains the other two ends to be disposed of. One of the ends must be stripped of its silk and soldered to the brass tube A, the other end must be stripped in a similar manner, passed through a hole in the ebonite plug at the other end of this tube, and soldered to the insulated spindle D.

Disposal of ends of wires.

This tube, with its projecting spindles must now be described. It will be noticed that the core-holder F is bored through with a hole $\frac{3}{8}$ inch in diameter. This hole must be tapped to receive the screwed end of a piece of brass tube, length $1\frac{7}{8}$ inch, fitted tightly with a steel spindle E; this is the contact spindle, the end of this spindle is shown in elevation at Fig. 5, representing the form to which this end must be filed and turned. Having fitted the contact spindle into the tube, the remaining part of it should be filled up with a closely-fitting plug of wood, or of ebonite. If the body of the tube has been filled up with a wooden plug, it will be best to fit an ebonite extension to the tube, as shown by the deeply-shaded part in the sketch. A hole must now be bored through the ebonite and into the plug to receive the end of the spindle D; this must be done with great nicety and exactly in line with the contact spindle, for if the centre of the two spindles are not exactly in line with each other an eccentric or wobbly motion will be given to the bobbins. It will now be seen that this spindle is insulated from all other parts by the ebonite and the wood. We must now bore a small slanting hole through the ebonite plug, bring one outer end of the wire from one of the bobbins through this hole; bare the end of the wire, clean this and the spindle with a scrap of emery cloth, wind the

Tube and projecting spindles.

Contact spindle and plug.

Insulation of spindle.

bare end of the copper wire around the spindle two or three turns and put on a drop of solder to secure it in contact. A strip of velvet passed around both coils and sewn between them will impart a finished appearance.

Before we pass on, let us note that, if the wires from a galvanic battery were connected to the spindles D and E respectively, the electric current must travel through all the wire on both bobbins, and also that any current set up in those wires must be taken off at D and E. When the bobbins are fixed in position in the frame and we turn them in front of the magnet, this makes snatches at the bobbins and their cores, and causes a current of electricity to pass through the copper wire wound upon them. If now we allow the spindles to run in a metal frame, the current of electricity will circulate through that frame outside the bobbins; but if we insulate one of the spindles from the frame by a bush of ebonite or of wood, we shall not get an external circuit for the electric current. As we do not desire to waste the current in a useless round through the frame, we bore a large hole in the frame for the end of the contact spindle; bush this hole with hard wood or with ebonite, and this again with a bearing of brass tube. The end of the spindle passes through this insulated bearing and runs in contact with the spring S (Fig. 2). By this arrangement there is no external circuit for the electrical impulses set up in the coils on the bobbins. To secure this circuit we have to add a separate part, consisting of a steel contact spring C, the form and size of which are shown at Fig. 6. If this spring was made to press equally on the rounded end of the spindle we should again short circuit the coils through the frame, and fail to get any external results. To avoid this, the end of the spindle is shaped as shown, Fig. 5. On referring again to Fig. 6, it will be seen that whereas a round spindle would be always in contact with the spring, this contact is avoided by filing the spindle on both sides, so that it only makes contact at each half-turn of the spindle. The coils are therefore short circuited through the frame at every half-turn of the spindle, and this circuit is broken at every other half-turn. This answers to the make and break contact apparatus of street medical and shocking coils, and the effect is similar, the shocks being given by the jerky impulses

Course of electric current.

Economisation of current.

Steel contact spring.

Short circuiting coils.

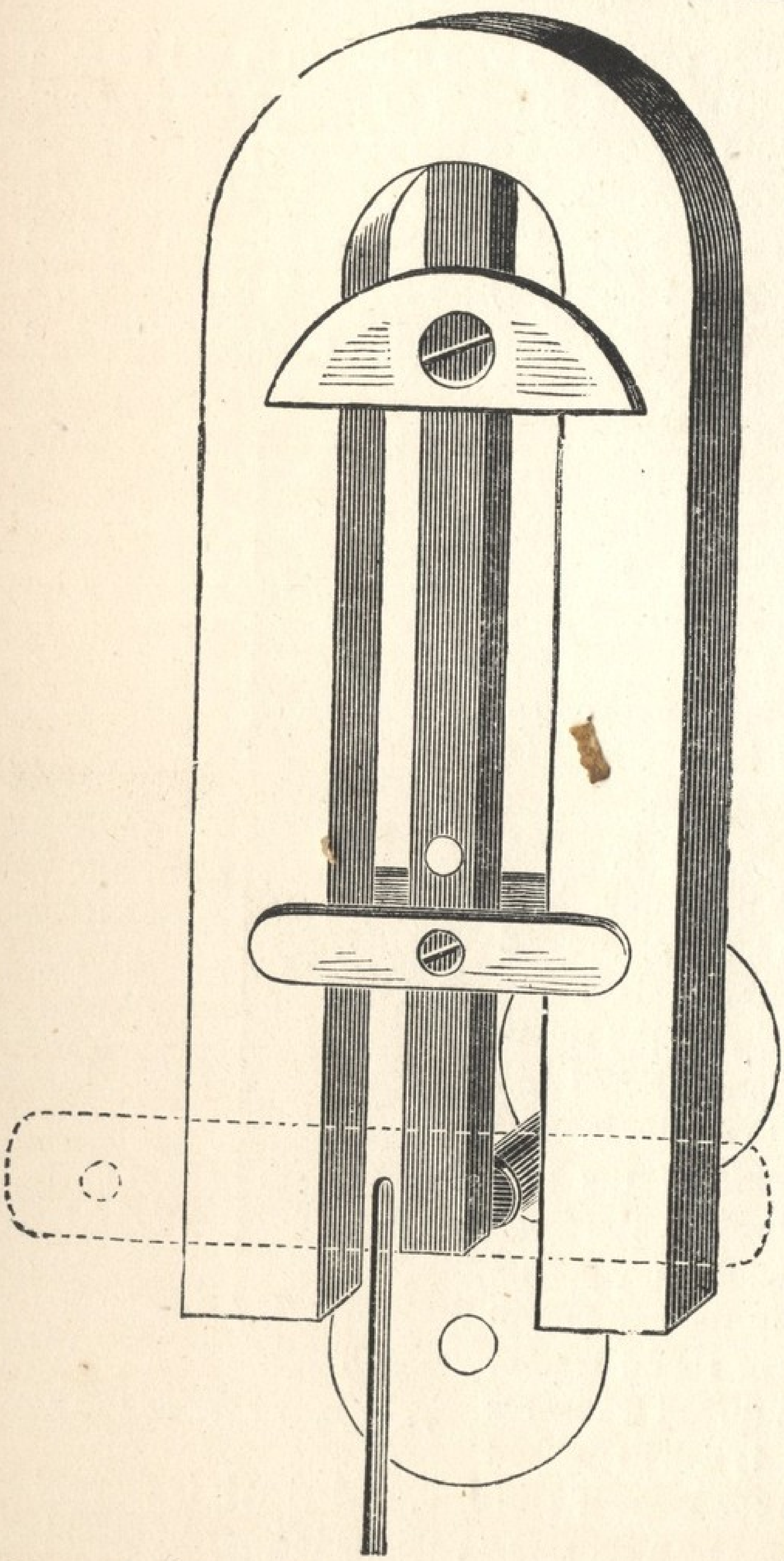


FIG. 7.—BACK OF MAGNET, SHOWING METHOD OF FASTENING IT TO FRAME, AND POSITION OF ARMATURE, BOBBINS, ETC.
Dotted lines show position of armature.

sent through the spring S to the stud F (Fig. 2), and through the frame to the stud E every time contact is broken at C. As the working of the machine depends on the perfection of this part, I have entered most fully into details concerning it. The other parts may be described in a few words.

Construction of frame.

The frame (fitted with a set of multiplying clock wheels consisting of a $2\frac{7}{8}$ inch driving wheel, containing 10 teeth to the inch of circumference, gearing into a pinion fixed on the spindle of the driving pulley). This frame is made of brass, $\frac{7}{16}$ inch by $\frac{1}{4}$ inch, and is usually cast in two parts, but it might be easily formed out of malleable brass, bent to proper form and secured by set screws. On reference to the plan (Fig. 2) the following points will be observed in the form of

the frame: A bracket-like projection with a hole in it, will be seen in the top left hand corner; this is made to receive the shank of the handle or key, when the machine is not at work; on the same side of the frame, near the bobbins, the frame appears to terminate, but does not really do so, but is here turned aside between the legs of the magnet, as shown at Fig. 7, where it is seen to support the end of the insulated spindle; at this point, also, two transverse lugs of brass spring out as supports for the magnet, which is here gripped between the lugs and a transverse supporting piece of brass on the other side, secured to the frame by a set screw, the curved part of the magnet being supported by another transverse piece, as shown Fig. 7. The frame is supported in the mahogany box by long screws at M and at C, and by the stud E, which is made to screw into the frame. The handle H is made to screw on the end of the driving spindle, this being screwed, and the shank of the handle bored and tapped to receive it. By this device the motion of the machine is always secured in the same direction; since, should any person turn it the wrong way, the handle will come off. A piece of round leather boot-lace sewn with thread will serve for a driving-band. It will be noticed that a slot is cut in the contact spring C, and that it is secured to the frame by a set screw; this is intended to facilitate adjustment, and it may be as well to state here that the action of the machine may be much impaired by a faulty adjustment of this part. The current is taken off by means of two handles made out of brass tube, connected by lengths of braided wire to two brass pins inserted in the holes of the studs E and F.

Supports of frame in box.

Handle and driving spindle.

Taking off current.

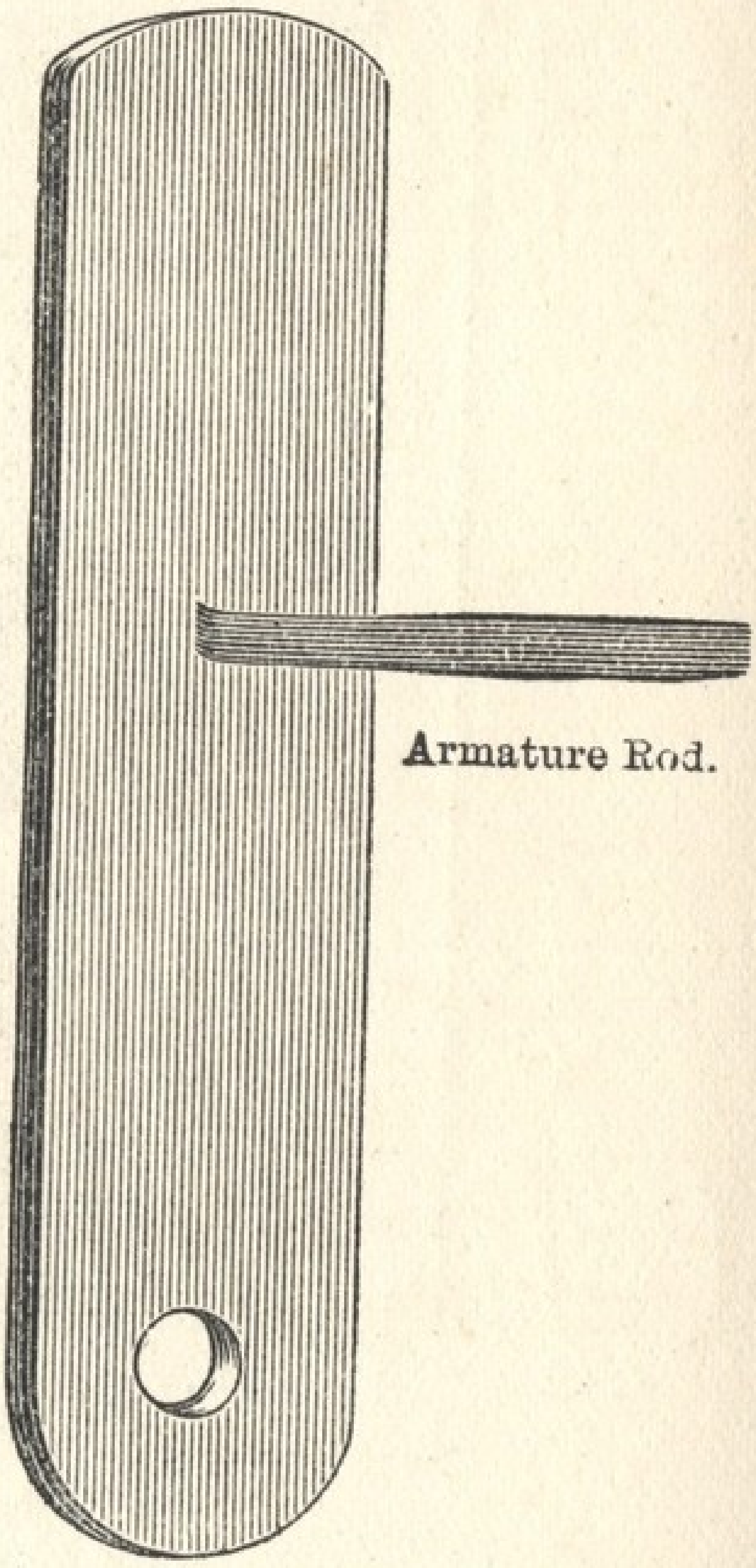


FIG. 9.—ARMATURE AND ROD.

The intensity of the current and the severity of the shocks may

be regulated partly by the speed of the machine, the "strength" of the shocks increasing with rate of speed. Apart from this, the strength of the current may be diminished or increased at will by actuating an armature A, by means of a knob and draw-bar K. A full-size sketch of the armature is shown at Fig. 9. It is simply a piece of bar iron, $3\frac{1}{4}$ inch by $\frac{5}{8}$ inch by $\frac{1}{4}$ inch, the bottom hole fitted with an iron pin $\frac{3}{4}$ inch in length, and the smaller hole in the position shown in sketch, fitted with a hook of $\frac{1}{8}$ inch brass wire, terminating outside the box in a brass knob. The use of this armature is to act as a divider of the magnetic influence of the magnet; that is to say, when the armature is placed upright against the magnet, as shown in sketches, part of the magnetic influence is exerted on the armature and part on the iron work of the coils; but when the armature is pulled away from the magnet to the position shown by the dotted lines in the plan, all the influence of the magnet is exerted on the revolving coils, and the strength of the current is increased. In fitting this armature we first bore a hole near the bottom of the box, and in the position marked T on plan, to receive the iron pin that forms the pivot on which the armature rests and moves. We then bend a hook on a piece of brass wire, pass it through the small hole of

Regulation of current and shocks.

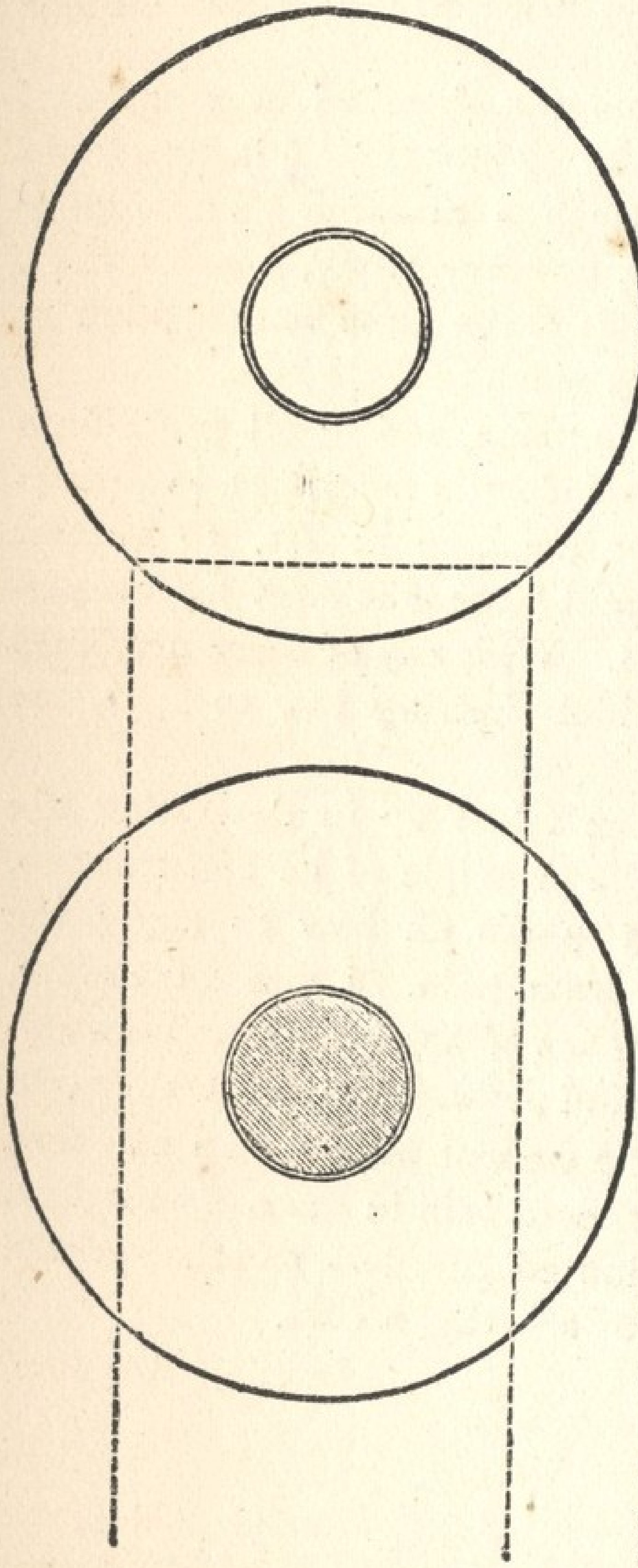


FIG. 10.—RELATIVE SIZE OF COIL BOBBINS AND THEIR CORES TO THE MAGNET. FULL SIZE.

Armature: its use and how to fit it.

the armature, and secure it there with a grip of the pliers in such a manner as to keep it from slipping out, but leaving it free to move in the hole; then bore a hole in the end of the box for the brass wire to pass through, cut it off when the armature is in the position shown on plan, and fit a small neat brass knob to the end of the wire.

The machine from which the plan was sketched was enclosed in a neat mahogany box, 10 inches by 4½ inches by 5 inches, fitted with lock and key. Such a machine was formerly sold by Mr. Dale, of 10, *Cursitor Street*, *London*, *E.C.*, for 18s. 6d., and any part of the same was supplied by him to amateurs wishing to make up machines.

Dale's magneto-electric machines.

Manufacturing electricians used to make, and in all probability still make, a speciality of this class of electric machines, in various forms, from a pocket machine at £1, to parlour machines at £1 13s., and large machines for bazaars and fairs at 15 guineas. With any of these machines the makers usually supply a pamphlet showing how to apply the current for medical purposes.

Small magneto-electric machines and pamphlet.

So much space has already been taken up in describing the manufacture of this machine and the principle of its construction, as to preclude any remarks on how to apply the current to give relief from pain. I must, therefore, hold back several sketches of appliances, and instructions for using them, much to my, and perhaps the reader's, regret. I will merely say at present that the current from such a machine, when properly applied, has often relieved pain in cases of neuralgia, rheumatism, gout, headache, and kindred disorders, and thus proved a useful auxiliary to other means for effecting a cure.

Application of current for medical purposes.

PART IV.

HOW TO MAKE A CYLINDRICAL ELECTRICAL MACHINE.

HOW TO MAKE A CYLINDRICAL ELECTRICAL MACHINE.

CHAPTER I.

THE PARTS: WHENCE PROCURED, HOW MADE, AND HOW PUT TOGETHER.

Introduction—Small glass cylinder—Stick as axis for cylinder—Caps on axis—Fixing caps in position—Handle for turning cylinder—Completion of handle—Cushion to rub against cylinder—Flap of silk and leather—Stand for cylinder—How to make the uprights—Stand for cushion—Brass knob and nut—Peparation of prime conductor—Pins in conductor—Wire and ball for conductor—How to fix conductor—Electrical amalgam—Application of amalgam—Caution respecting cylinder and conductor—Caution respecting points—Tightening cushion: why necessary—Renewal of preparation of machine—Storage of electricity—Leyden jar: how to make it—Brass ball for jar—Wooden stopper—Making machine work—Transmission of electric fluid—Discharging rod—How to use the rod—Points requiring attention to insure success—Plate machine.

Introduction.

WITHOUT any preliminary or unnecessary remarks, I shall at once proceed to show how anyone may make, at a moderate outlay, a small electrical machine, by means of which a severe shock may be sent through as many as a dozen or more people who are joining hands.

Small glass cylinder.

The first thing necessary to be procured is a small cylinder. One about 6 in. long by 3½ in. in diameter may be bought of any dealer in chemical and experimental glass apparatus for about 1s. 8d., and larger sizes at proportionate prices. I may here mention that such dealers generally supply any or all of the requisite articles for the machine about to be described. Having procured the cylinder, take a square stick of any hard wood about one foot long, make it round like an ordinary blacklead pencil, only rather wider in diameter than the holes at either side of the cylinder into which the stick will have to be placed. Try if the stick will go into the

Stick as axis for cylinder.

holes; if it be too large, reduce the size slightly by rubbing it with glass-paper. Again try if it will go into the cylinder; if still too large, rub a little more with glass-paper, but be very careful and not make the stick too small, for it must almost be forced into the cylinder, for when the machine is in work the stick will act as a pivot for the cylinder to turn on, and consequently must fit so tightly that it would be almost impossible to move it.

Assuming the stick is in the cylinder, with an equal length being left on each side, and that it is so closely fitted that it will not move, the next thing to be done is to make two caps. To do this, take a square piece of hard wood about $\frac{3}{4}$ inch larger than the outside measurement of the necks of the cylinder, round off the corners with a rasp or file until you have made it look like a lead pencil uncut—that is to say, a roller with each end quite flat. Now mark on one of the flat ends the size of one of the necks of the cylinder, and hollow out the part so marked with a chisel or other convenient tool as deep as the neck of the cylinder. Having done this, bore a hole through the remainder of the block, but large enough *only* to allow the end of the centre stick to pass through easily. Next round well off the corners which are to be outside or furthest from the cylinder, *for in all electrical machines there must be no corners nor rough edges, everything must be well rounded off. This is an important condition for the successful working of the machine, and I would call the reader's particular attention to it.*

Caps on axis.

If this cap now fits well, make another exactly similar for the other side of the cylinder, and in order to keep them in a fixed position, a small French nail (the head of which has been previously taken off) may be driven through the cap into the wooden stick.

Fixing caps in position.

The next operation will be to make a handle to turn the cylinder. For this purpose take a piece of hard wood, say 5 inches long, $1\frac{1}{2}$ inch wide, and $\frac{1}{4}$ inch thick when finished; at one of the ends cut a square hole just large enough to admit one of the ends of the sticks which runs through the cylinder, which of course will have to be squared to the same size, and about $\frac{3}{4}$ inch down, so that when the handle is put on the cylinder, there will be $\frac{1}{2}$ inch of the squared stick extending beyond it. Make the handle fit as accurately and as tightly as possible, for

Handle for turning cylinder.

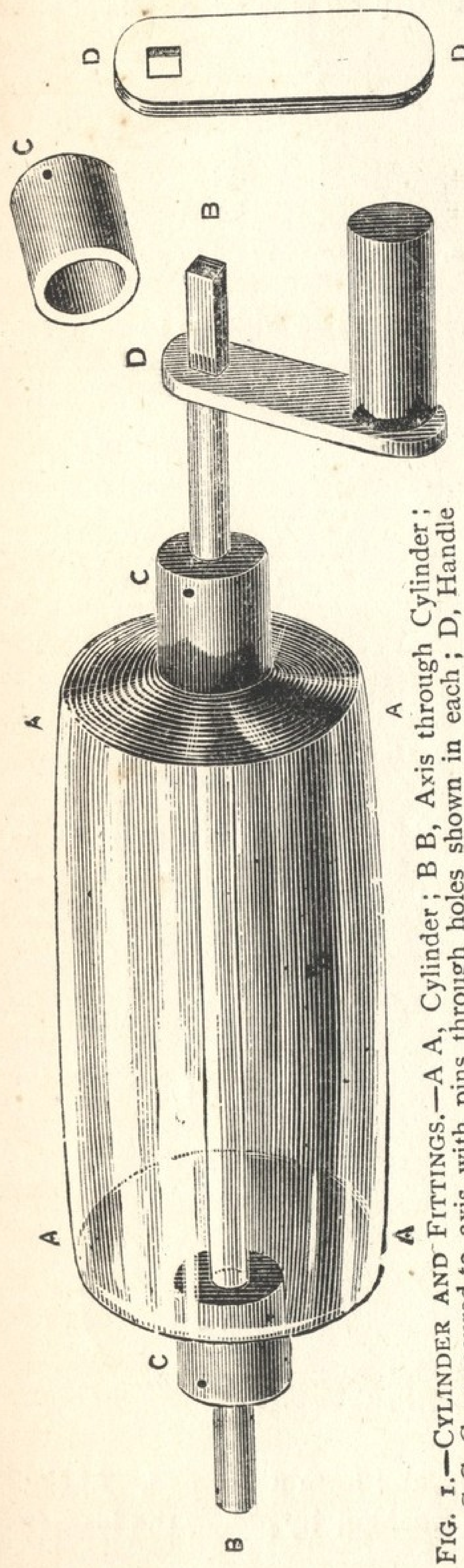


FIG. 1.—CYLINDER AND FITTINGS.—A A, Cylinder; B B, Axis through Cylinder; C C, Caps secured to axis with pins through holes shown in each; D, Handle secured with pin passing through squared end of axis.

if it should get loose while working the machine, it will cause endless trouble and annoyance. When the handle is on, drive a headless French nail through the centre stick outside the handle, and as close to it as possible, so as to prevent it coming off again.

Completion of handle.

To complete the handle, take a roll of wood 1½ inches in diameter and 4 inches long, round off the ends, and fit it with an ordinary screw to the other end of the part already joined to the cylinder. It is of course needless to say that this part of the handle must *not be fixed*, but must move freely, so that when it be turned, the part intended to be held will be unmovable in the hand. The sketches in Fig. 1 will help to explain more clearly the foregoing instructions.

The next thing to make is a cushion to rub against the cylinder. For this take a piece of wood ½ inch thick, one inch wide, and in length about 1 inch less than the sides of the cylinder. Cut a notch in the middle of the back of it, or, to speak more strictly, in the middle of one of the flat sides, and let the

notch be about $\frac{1}{8}$ inch deep, and nearly an inch wide. This piece of wood is shown in Fig. 2. Then cut a piece of coloured thin leather (which may be obtained of any bootmaker) one inch longer than the wood, and as wide as to go nearly

Cushion to rub against cylinder.

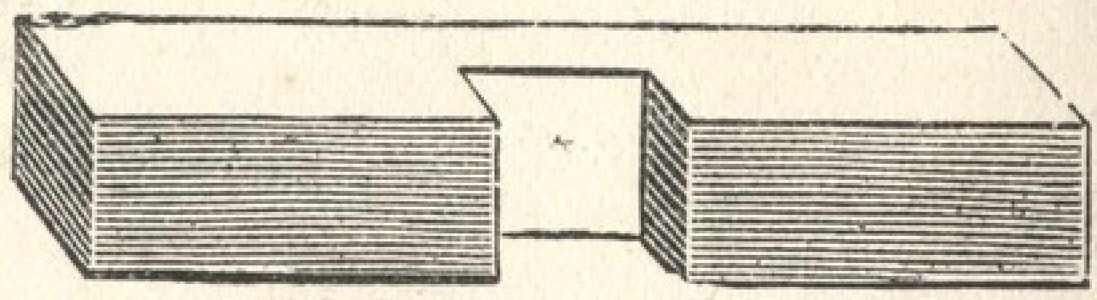


FIG. 2.—FOUNDATION OF CUSHION.

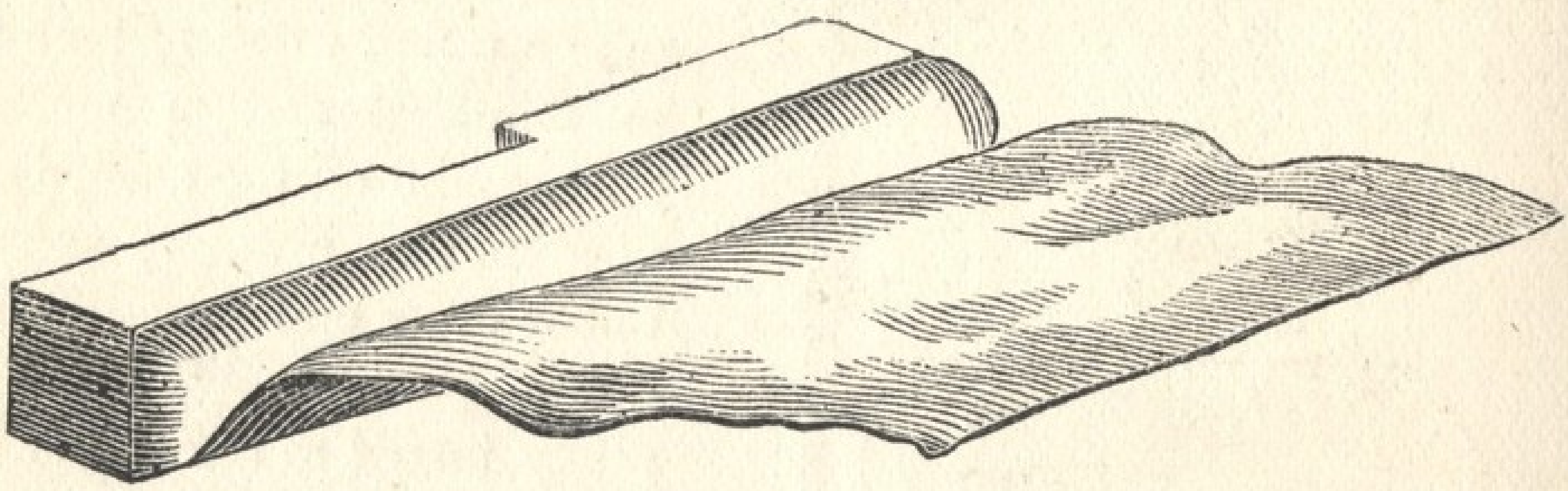


FIG. 3.—THE CUSHION WITH SILK FLAP.

round it. Glue this leather at the top and bottom of the wood, so that it passes over the front of the wood loosely, that it may be

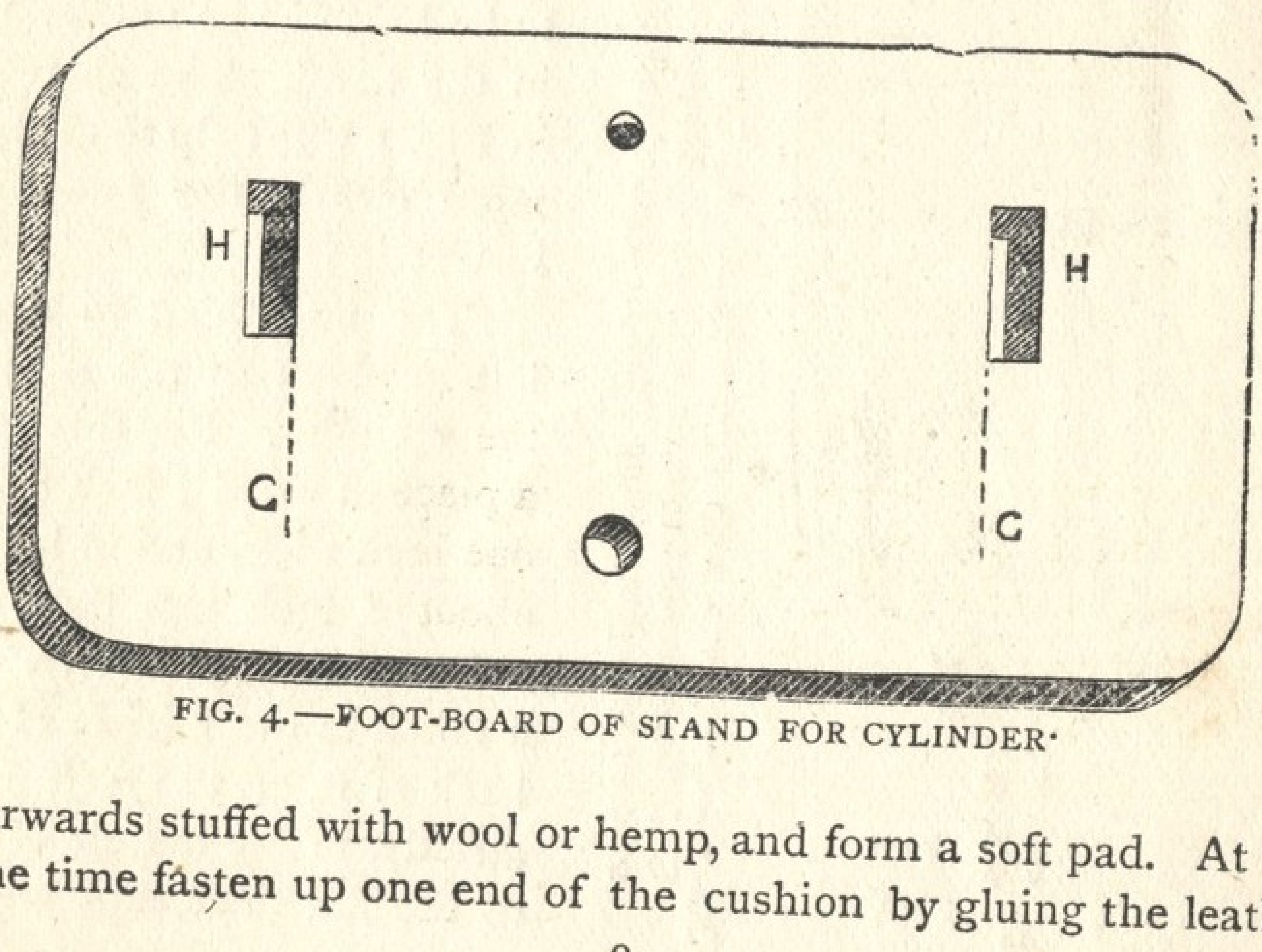


FIG. 4.—FOOT-BOARD OF STAND FOR CYLINDER.

afterwards stuffed with wool or hemp, and form a soft pad. At the same time fasten up one end of the cushion by gluing the leather

carefully and smoothly over it. Now let the glue dry, and when dry, stuff the cushion by the aid of a wire, and fasten up the other end with glue. It will next require a flap of leather and silk. Decide now which end of the cushion shall be the bottom, and that being fixed upon, glue a second piece of leather of the exact length of the cushion upon the first piece along the lower edge, but not anywhere else, observing that as the first leather had its coloured side outwards, this piece must have its coloured side inwards; and consequently it is the coloured side which is glued down to the former. When glued on, cut the flap, so that its upper edge shall reach exactly to the top of the cushion, and no further, then glue a piece of thin sarsenet along this upper edge, it will be wanted of the same width as the leather flap and four or five inches long. *It must be of a black colour, and ought not to have the edges hemmed.* The cushion complete is shown in Fig. 3.

Flap of silk and leather.

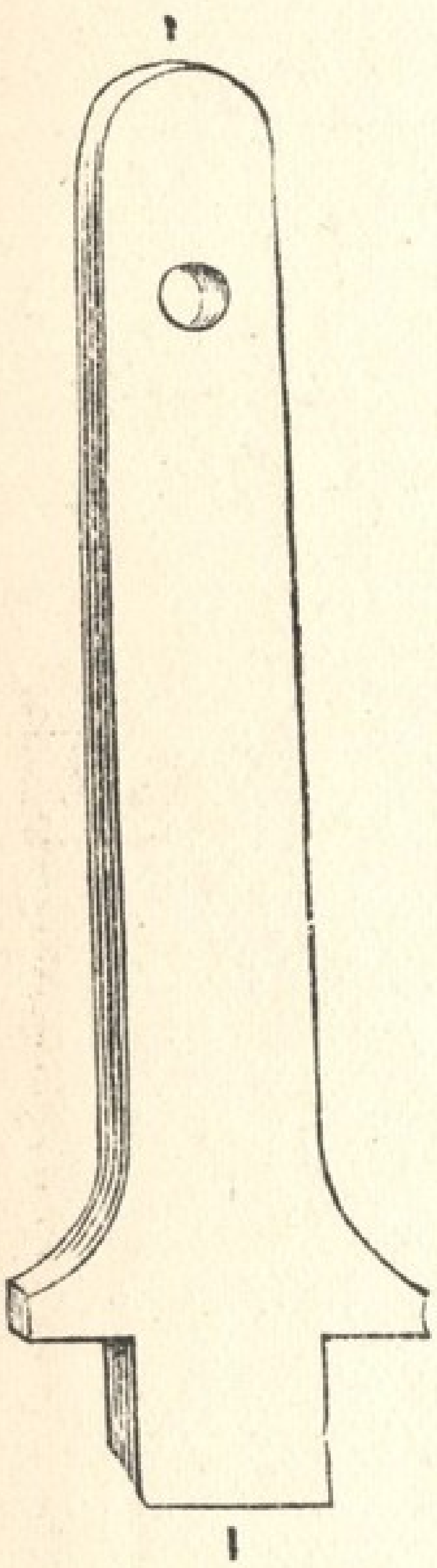


FIG. 5.—UPRIGHT.

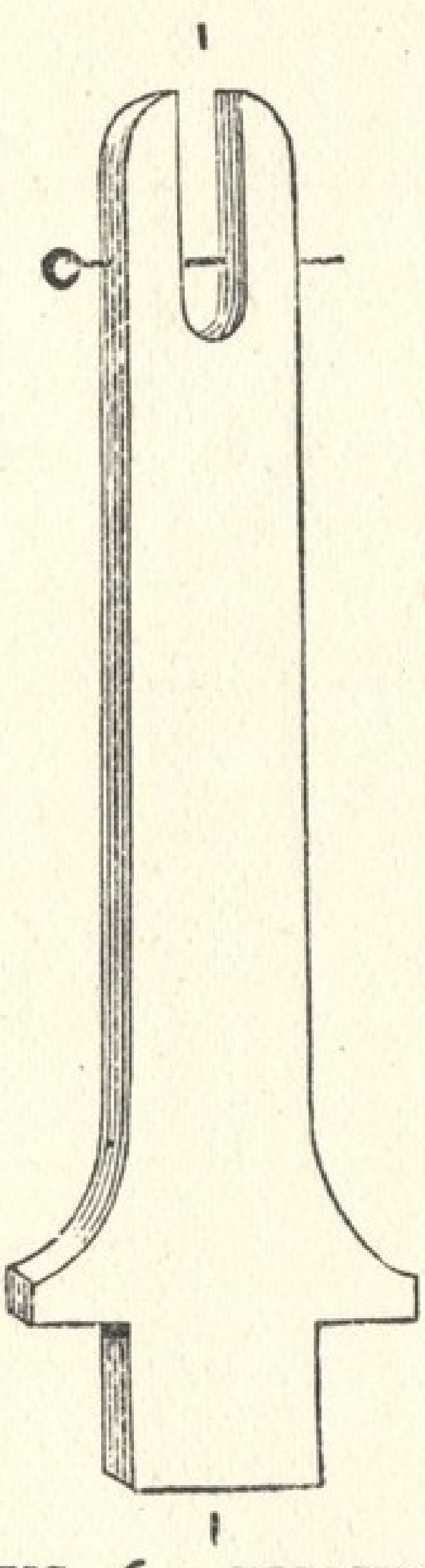


FIG. 6.—UPRIGHT FOR HANDLE-END OF AXIS.

Now that the cushion is made, it will be well to make the stand for the cylinder, and one also for the cushion. For the first of these, procure a piece of flat smooth wood, about 1 foot long and 9 inches wide, and an inch or more thick, round well off all the edges and corners and make them quite smooth, then measure the length of the cylinder with its caps on it along the piece of wood (measurement from the end of one cap to the end of the other, take no notice of the stick extending beyond), which I will suppose to be indicated by the dotted lines G, G in Fig. 4. On the

Stand for cylinder.

How to make the uprights.

outside of these marks cut two holes as at H, H, quite through the board. Then make two uprights as in Figs. 5 and 6. The lower

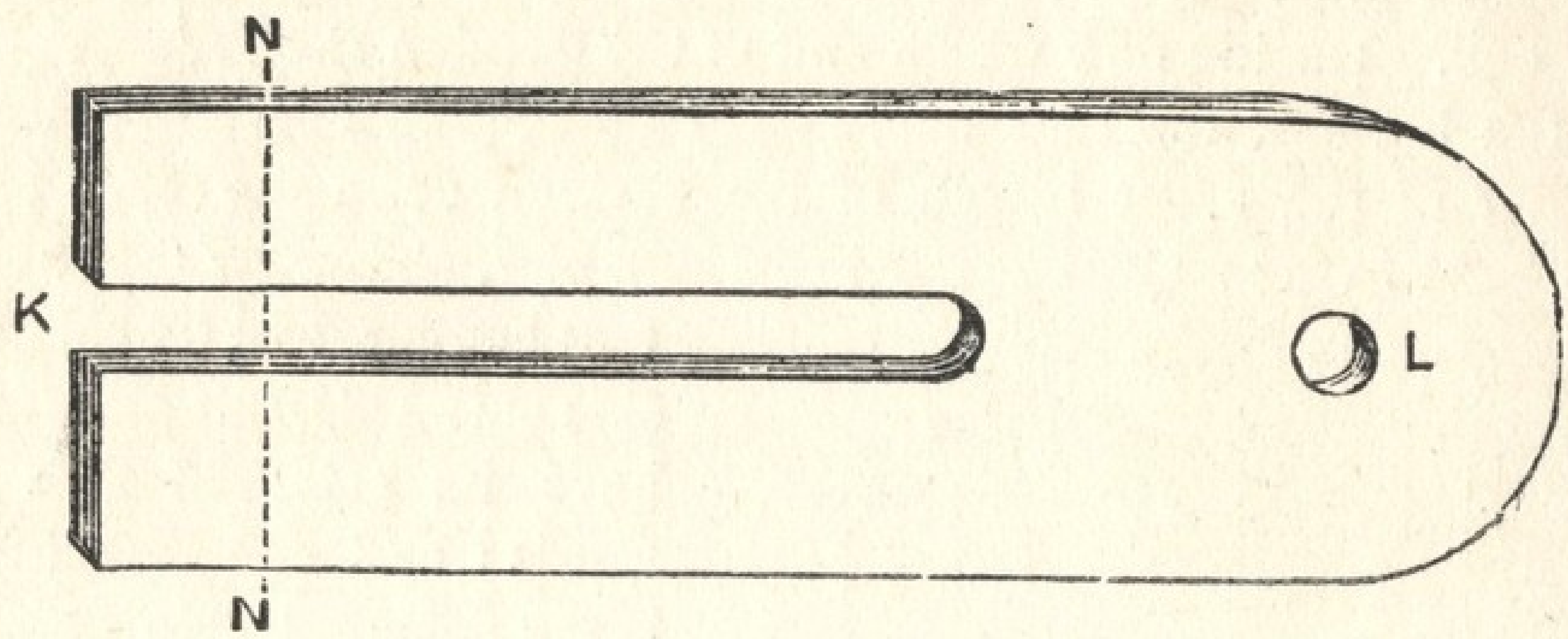


FIG. 7.—FOOT OF CUSHION.

end of each is to fit into the holes H, H. These uprights may be 8 inches above the board when fixed into their places. The upper end of one of them (Fig. 5) is to have a hole bored in it with a centre bit just slightly larger than the end of the pivot of the cylinder, which will revolve in the former. The end of the other upright (Fig. 6) is to have a slit made down the top (stopping on a level with the hole in the other one) for the handle end of the cylinder to rest in, where it is to be secured by a piece of wire passed through the upright when the cylinder is in its place —this wire is seen at I Next procure a strip of hard wood 1½ inch wide, ½ inch thick, and 3 inches long, cut a hole along one part of it as at K (Fig. 7), and drill a hole ½ inch in diameter at another part,

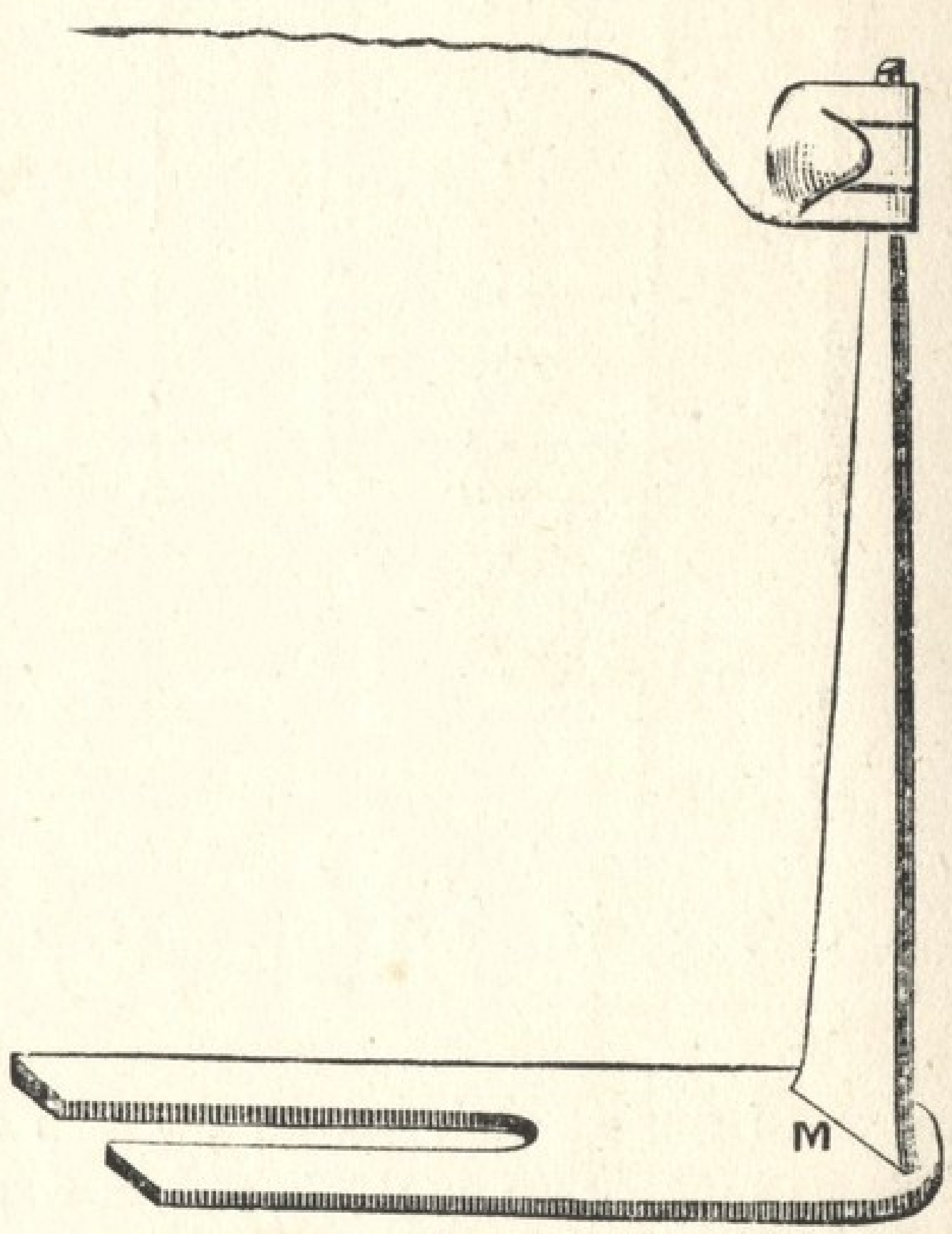


FIG. 8.—THE CUSHION AND FOOT, COMPLETE.

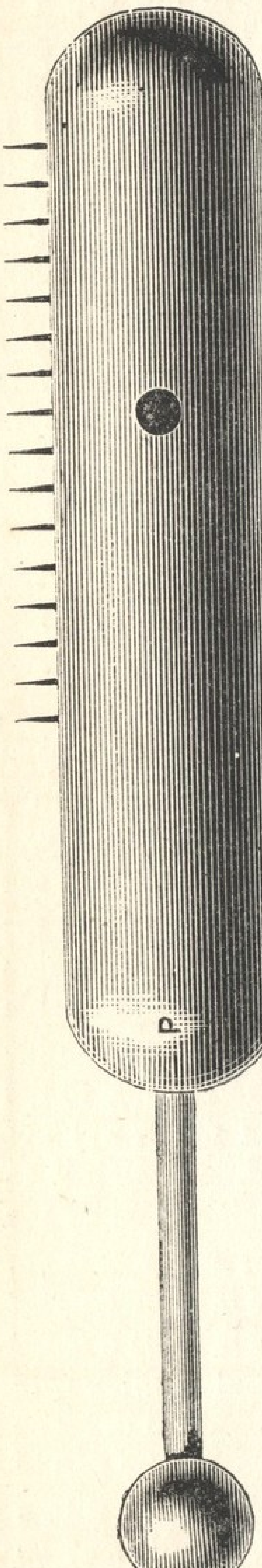


FIG. 9.—THE PRIME CONDUCTOR.

as seen in the sketch at L, then get a flat piece of wood, cut it at one end to fit the hole L, and gradually make it thin towards the top end, and let it be of the same length as the uprights. Glue it to the foot-piece as seen at M, and glue the cushion on the upper end of it, at such a height as that when the foot-piece is made to rest on the board of the stand, the centre of the cushion shall be of exactly the same height as the pivot holes in the uprights. Now put the cylinder in its place, and place the cushion against the side of the cylinder, resting its foot upon the stand, and letting the handle of the cylinder be to your right hand with regard to the cushion. To be quite clear on this point, supposing the cylinder to be lengthways in front of you the side for the cushion is the one nearest you, the side furthest from you (as we shall see later on) is for the prime conductor. Well, having put, as just stated, the cushion in its place, see that it is of the right height to reach the most projecting part of the cylinder, and that it is of the same distance from each end of the length of it. Hold it so close as to touch the cylinder, and make a mark on to the board, close to the end of the slit—say at about the dotted lines at N N. Bore a hole at this mark, and get a brass knob from any ironmonger's, which has a nut to fit the screw of it. The larger and stronger this knob is, the better. I may mention that the length of the screw must be $\frac{1}{4}$ inch shorter than the thickness of the cushion foot, and the foot-board together.

Stand for cushion.

Brass knob and nut.

Let the nut into the under side of the foot-board, to the depth of ½ inch. Now put the complete cushion (Fig. 8) in its place, and, putting the screw in the proper hole, it will hold the cushion securely, and the silk flap will go over the top of the cylinder. It is almost needless to mention that the width of the upright for the cushion is to be exactly that of the notch at the back of it, as previously described.

Preparation of prime conductor.

The next thing to make and fix is the prime conductor (Fig. 9.) For this purpose get a round piece of wood about 6 ins. long and 2 ins. in diameter, cut and file the ends round, and cover the *whole carefully* with tinfoil, which may be bought of dealers in glass apparatus at about 2½d. per ounce, stick it on the conductor with ordinary paste, cut it into notches at the ends, that they may lay over one another without any unevenness, let it get thoroughly dry, and then rub it all smooth with the handle of a knife. Now make a line along the conductor rather towards one end of it, and with a very fine bradawl make small holes along it about ¼ inch apart; into these holes drive pins (the heads having been previously taken off), leaving the points standing outwards about ½ inch. The sketch given in Fig. 9 will indicate this more clearly.

Pins in conductor.

There may be about fifteen pins, and the whole length of the row may be rather less than the length of the cushion. Hold the conductor to the cylinder on the opposite side to where the cushion is, so that the end P may be to the right hand (looking at the side where there is no cushion) or the end removed from the handle. It will not be seen that the conductor, owing to the pins being nearer to one end than the other, will not be exactly in the middle of the stand. When it is so held, mark that which is the under side, the pins being towards the cylinder, and in that under side bore a hole, ½ inch or more deep, and the same in diameter, the position of the hole is to be equally distant from both ends of the line of pins. There is to be a small hole made at the longest end of the conductor, and a thick wire with a ball at the end of it, driven into it as represented at O. The ball and wire at the end of the conductor may be of any sort of metal, brass certainly looks best, but a piece of iron wire with a bullet at the end of it, answers every purpose. Brass balls may be bought ⅜ inch in diameter for 3d., or ½ inch for 4d.

Wire and ball for conductor.

The conductor is now complete, and ready to be fixed. To do this, buy a glass rod, half-an-inch or less in diameter, and as long as the uprights, which will be about nine inches. This may be bought at the rate of 1s. per pound. Simply

How to fix conductor.

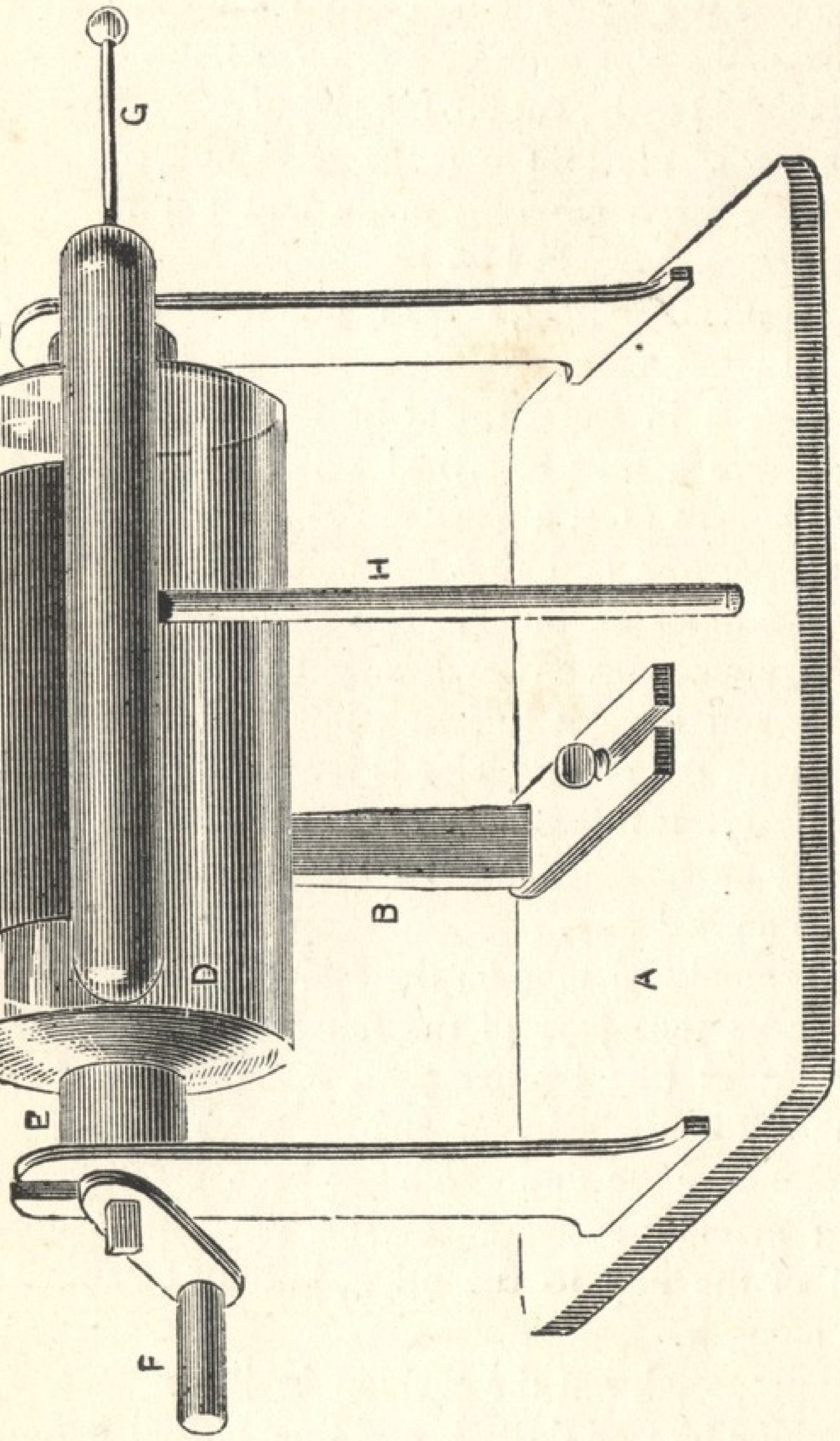


FIG. 10.—MACHINE COMPLETE.—A, Stand; B, Upright of Cushion; C, Silk flap of Cushion; D, Cylinder; E, E, Caps; F, Handle; G, Prime Conductor; H, Glass Rod supporting Conductor.

say you want nine inches of glass rod, of half-an-inch in diameter, and that quantity will be weighed and charged for accordingly. Having procured the rod, roughen both ends for about half-an-inch on a grindstone, or with a file, and cement one end into the hole

underneath the conductor, and when fluid hold the conductor in its place, so that the row of pins is in the middle between the two ends of the cylinder, and mark where the glass rod touches the foot-board, bore another hole here, and cement the rod in, at such a height as that the points shall agree with the pivot and cushion, observing also that the hole should be so far back, that when the conductor is fixed, the pins shall be about a quarter-of-an-inch from the cylinder itself. Lastly, cut off the silk of the cushion in a line just above the row of pins. The machine is now complete, and if all the parts have been correctly made and put together, it will have the appearance shown in Fig. 10.

Assuming all this is perfect, there is no doubt that with a little contrivance and good management sparks an inch long may be obtained. To put it in work, it will be first necessary to make or procure a little electrical amalgam. It can be made as follows : Get a piece of zinc about as large as a pea, melt this in a pipe, and add to it one ounce of quicksilver, which will be about five times as much. Stir them together, and when properly united, pour them on the hearth to cool ; when cold, the mixture will be soft enough to break into pieces with the fingers, or to cut easily with the knife. This is ready for use, and will keep any length of time. If it is thought too much trouble to make the amalgam, it may be bought ready for use for 6d. per ounce, which quantity will go a good way.

Electrical amalgam.

To apply the amalgam, take off the cushion, grease with the end of a tallow candle that part of the flap which goes next to the cylinder (the leather part, *not* the silk), taking care that it is applied very sparingly. Then spread a little of the amalgam over the flap which has been greased, till it presents a bright metallic appearance—this amalgam should extend from one end of the flap to the other, but not be above half-an-inch in width along it.

Application of amalgam.

This being prepared, put the cushion in its place, and then let the whole machine be well dusted, and then placed before the fire so as to get gradually and equally warm all over Dust it well again, lest any ashes should have settled on any part of it, and do this with a very dry warm *silk* handkerchief or a piece of flannel (the former is preferable), and particularly see that the *ends of the cylinder beyond the cushion*,

Caution respecting cylinder and conductor.

and the leg of the conductor are quite dry. This is most important as a little breath even on the rod of the conductor would cause a failure. Fasten the cushion, so that it presses slightly against the cylinder, remove the whole from the fire, and place it on the table. If the machine be in good order, any person who holds his knuckle to the ball of the conductor will receive a spark, immediately afterwards another and another, so long as the machine is being turned. It would be a good plan to have a clamp to the machine to fix it to the table, as then your left hand would be at liberty.

Caution respecting points.

All the above directions are very plain, and the whole management of the machine so very easy, that with little care one is sure to succeed. But in case a difficulty is encountered, the following caution must be attended to. The electric fluid is always collected by a point; that is the reason that a row of points is along the conductor towards the cylinder--to collect the fluid from the cylinder. *Any point, therefore, which is near the cylinder draws the fluid away from it.* To a small degree other shaped bodies draw off the fluid, so does flame, therefore care is required when the machine is in use that nothing stands near it—no candle, no pin, nor needle, no finger pointed at it, no noses, no sticks, no elbows. Take care also that there is no dust upon the machine and no filaments of threads, for every particle is a point drawing away the fluid. And above all things, see that the cylinder and conductor leg are *perfectly dry;* therefore, do not breathe upon them, and for so small a machine it would work the better if it were warmed every quarter of an hour or so. If the handle turn very easily, tighten the cushion, for it should be so tight that there is a good pressure between the cushion and cylinder, and yet not so much as to cause any part of it being broken. If on turning back the flap, the cylinder looks very greasy and black with worn amalgam, it is because there is too much tallow; it must be wiped clean, which may be done without disturbing any part of the machine, by holding a silk handkerchief against the cylinder when being turned round. If the handle turn stiffer after a few turns than it did at first, it shows that the machine is in good working order; if it turn too stiff, however, warm the flap and wipe the cylinder; if this will not do, loosen the cushion. When the

Tightening cushion: why necessary.

machine ceases to act, certain it is that some dust or damp is clinging to it, perhaps a hair.

These cautions being observed, success is certain. I may mention that the same preparation of the machine is required every time it is used, except that much less tallow and amalgam are wanted after the first application of it, as what is on before need not be removed, unless it has got very old and hard. In larger machines than the one described, a chain is usually hung from the cushion to the table, as the fluid is more easily collected from the ground. This addition to a small machine would do no harm; on the contrary, it might work the better for it. When the machine is laid aside, always loosen the cushion.

Renewal of preparation of machine.

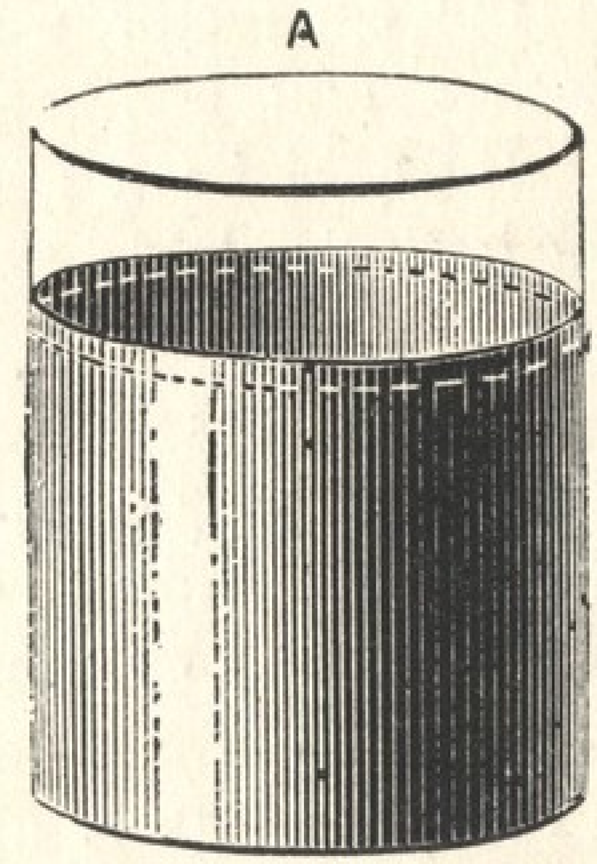


FIG. 11. — GLASS JAR COVERED WITH TIN FOIL. Dotted line shows height of foil inside.

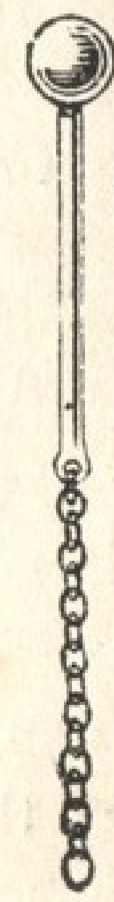


FIG. 12. — BRASS BALL, ROD AND CHAIN.

The machine is now quite complete, and will collect and produce electricity; but now comes the question of storing it — that is to say, of collecting a sufficient quantity for producing striking effects. For this purpose a Leyden jar is necessary. These of course can be bought, with polished mahogany tops, brass rods, and balls complete, at the following prices:

Storage of electricity.

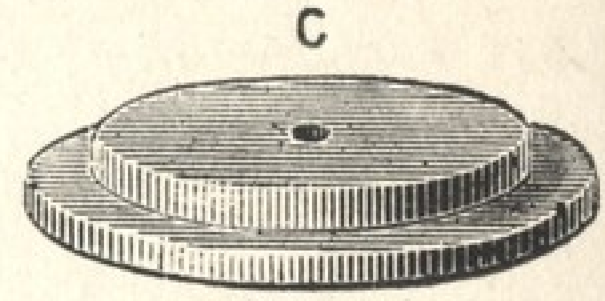


FIG. 13. — WOODEN CAP FOR JAR.

Capacity . . .	$\frac{1}{2}$	1	$1\frac{1}{2}$	2	3	4	pints
Price	2/6	3/6	4/6	5/6	7/-	9/6	each;

but it may not be convenient for some who will interest themselves in making an electrical machine to lay out five or six shillings in purchasing one, and this would be necessary to obtain one of the size I would recommend, viz., 2 pints. I will therefore describe how one may be made for certainly not more than 2s. Procure a

glass jar (Fig. 11), say about 4 or 5 inches in diameter and of 2 pints' capacity, being careful to see that there are no flaws nor cracks in it, as it would then be no good whatever. Next cut a piece of tinfoil the width of about three parts the height of the jar and rather longer than to go round it *inside.* Decide which is to be the bottom, and then cut little notches all along the length of it. This tinfoil is to be pasted with ordinary paste *inside* the jar, the notched part being arranged very neatly and evenly at the bottom. Now cut a disc, also in tinfoil, the size of the jar, or perhaps rather less, paste it, and fix

Leyden jar: how to make it.

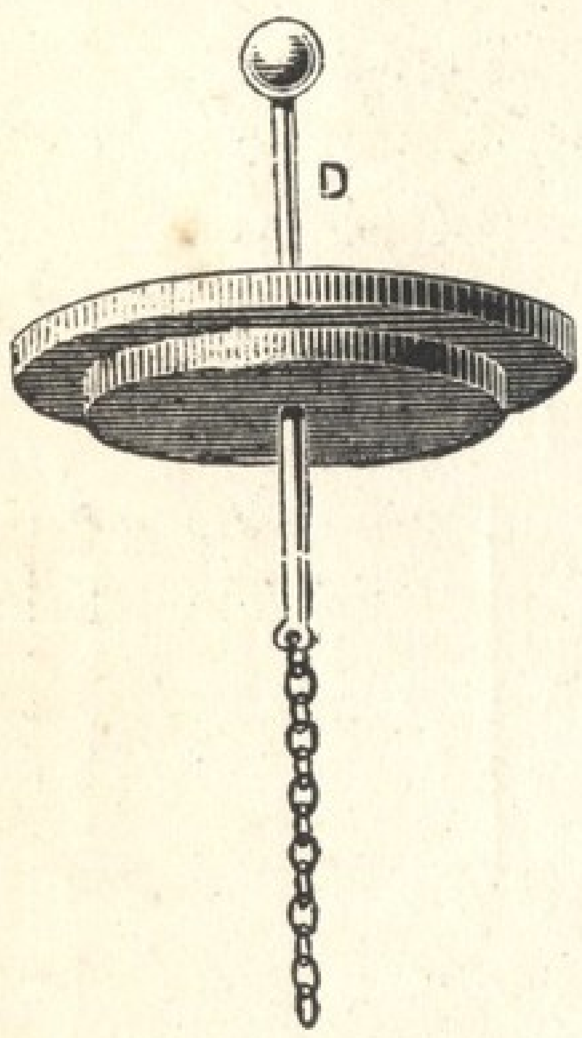


FIG. 14.—CAP, WITH BRASS ROD, ETC.

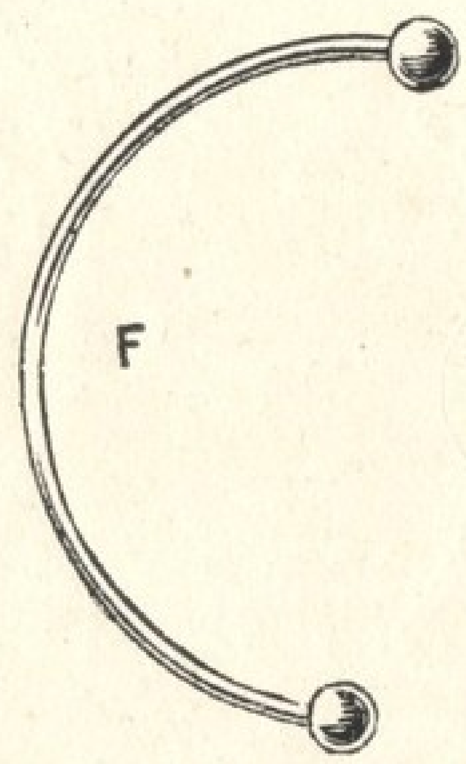


FIG. 16.—DISCHARGING ROD.

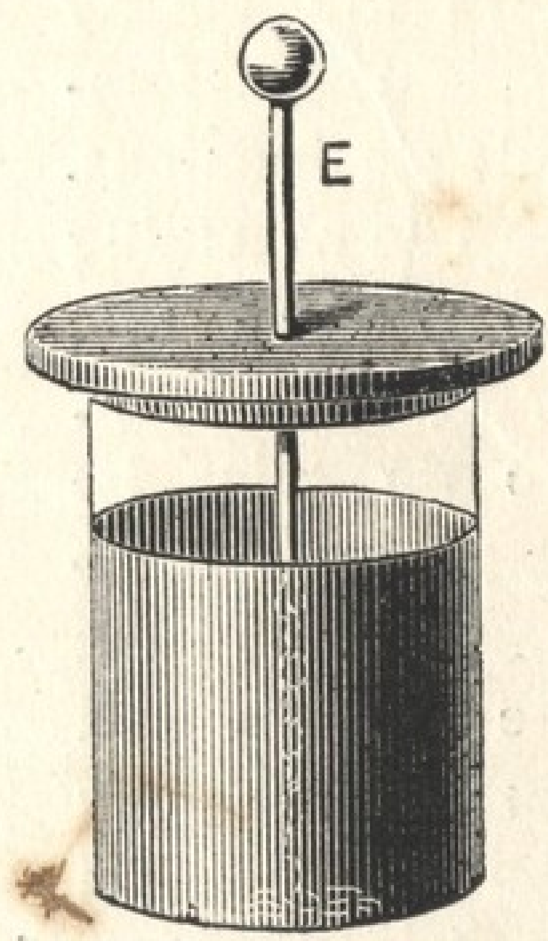


FIG. 15—JAR COMPLETE, READY FOR USE.

it to the bottom of the jar *inside.* See that this, as well as that which has been pasted on the sides, is all perfectly even—no rough edges nor ridges. Now cut another piece of tinfoil, rather longer than to go round the jar *outside*, and in width, to be when pasted on the jar about a quarter of an inch above the tinfoil inside. Notch again the bottom side, paste it carefully and evenly on the *outside* of the jar, and turn the notched part nicely under the bottle. Lastly, cut another disc rather smaller than the bottom of the jar, and paste that on. Now get a brass ball (Fig. 12) such as you had for the prime conductor, and fix it to a brass rod about six ins. long, at the other end of which drill a hole and insert the end link of a brass chain about nine

Brass ball for jar.

inches long. Next cut a disc of ½ inch wood, exactly the size to fit pretty tightly inside the top of the jar, and then cut another, one inch larger in diameter, smooth the edges well, and glue one on the

Wooden stopper.

top of the other (Fig. 13). When it is done it will have the appearance of a kind of stopper for the jar. When the glue has thoroughly dried, bore a hole in the middle of the stopper of the exact size of the brass rod, which latter is to be inserted in the former (Fig. 14). Put the wooden stopper of cap on the jar, letting the chain go into the jar and rest on the bottom, and leaving the brass ball outside (Fig. 15). The illustrations given in Figs. 11—15 will clearly explain the foregoing instructions.

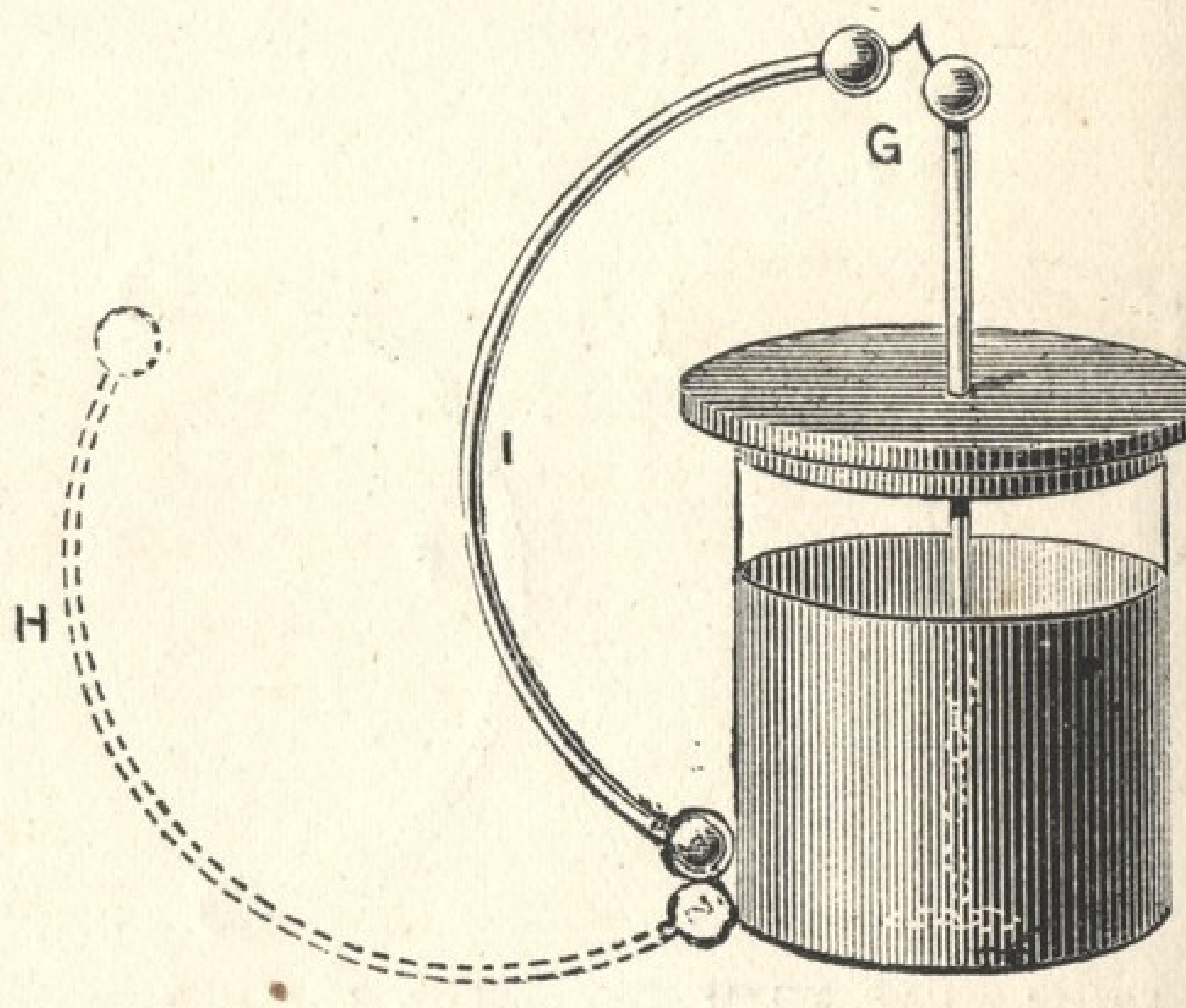


FIG. 17.—DISCHARGING ROD IN OPERATION.

The next thing is to make it work, or to charge it. To do this, be very careful to warm it, and let the uncovered part of the glass above the tinfoil be wiped clean, and perfectly *dry*. Then, having the machine in per-

Making machine work.

fect order, bring the Leyden jar to it, and let the brass ball rest against, or be very near to, the ball of the conductor, turn the handle (in an outward direction, of course, having the handle of the right hand), and sparks will pass from the conductor to the jar, which will be seen when the jar is held a little way off.

When, say, you have turned the handle ten times, remove the jar from the machine by catching hold of it as near the bottom as possible on the tinfoil. Remain holding it, touch the brass ball with the knuckle of the other hand, and you will, the instant you do this, receive a shock which will pass through your two arms. I dare say, with only ten turns of the machine, the shock will not be

disagreeable; next time give fifteen turns, and then twenty, and so on, and you will soon get to know what strength of shocks so many turns will give. You may give a dozen people a shock all at one time; let them join hands, and let the person at one of the ends take hold of the outside coating of the jar, and the person at the other end touch the ball quickly with the knuckle. I say quickly; for if it is done slowly it will draw off the fluid without producing any effect. I may mention that all will feel the shock equally; the ones touching the jar will feel no more than those in the middle of the circle. To pass the shock through twelve persons I would try forty times to begin with.

Transmission of electric fluid.

Perhaps some of my readers would rather not receive a shock, and yet would be equally desirous of seeing the effect; this they can do by using what is termed a discharging-rod. It consists simply of a piece of stout brass wire, bent as shown in Fig. 16 and having a brass ball fixed at each end :—

Discharging rod.

When the jar is charged with the fluid, hold it with the left hand as near the bottom as possible, and take the discharging-rod in the other; keep one ball of the said rod touching the outer coating of the jar, and let the other ball of the rod touch the ball of the jar, and immediately before the two balls touch, the fluid will pass in the form of a spark. This operation will be readily understood by the foregoing engraving. At H will be seen the position of the rod before discharging, and at I the position when in the act of being discharged; G is the spark passing from the jar to the rod. In this way the jar can be discharged without anyone feeling the effect of the shock.

How to use the rod.

I will now briefly repeat my cautions, which must be rigidly attended to in order to insure success. First, let the machine and jar be quite free from dust, hairs, etc.; secondly, let them be thoroughly warmed before the fire before using, so as to get rid of any moisture that may be on either, though, perhaps, invisible to the eye. And in wishing success to every one who may attempt to construct an electrical machine from the foregoing instructions, I may mention for their own satisfaction that a shock from a machine of the size described will never injure anyone if passed through the arms; but, at the same time, would advise them to be careful not to experimentalize on persons of weak hearts or of delicate constitutions.

Points requiring attention to insure success.

The form of electrical machine that we have been considering takes its name from the construction of the glass that is brought into contact with the cushion rubber in order to obtain a supply of electricity by friction. There is, however, another form of machine,

Plate machine.

known as the plate machine, and so named from the fact that the glass which is used in its construction is a plate or disc of thick plate glass, and not a cylinder. This disc is mounted on an axis passed through its centre, and supported on two uprights raised on a flat stand, and connected at top by a transverse piece of wood of the same breadth and thickness as the uprights. Contrivances are fitted to the foot of the stand, and to the bar that connects the uprights for the support of two pairs of rubbers or cushions, between which the disc is made to revolve, and which are so brought into contact with the plate as to press firmly against it. Flaps of oiled silk are attached to the rubbers, each passing over about a fourth part of the circumference of the disc, and prevented from being displaced by the friction of the plate when in revolution by threads which are attached to fixed points in the machine. The prime conductor, insulated by means of a glass stem in the same straight line with the axis, but on the opposite side to the handle by which the axis is turned, is in the form of an arc having at the ends arms with knobs close to and parallel with the face of the disc, by which the electricity evolved is received, and another knob at the end of a short arm proceeding from the centre of the arc, also in the same line with the axis and insulator, from which the electricity is received and stored in a Leyden jar, as in the cylindrical machine.

PART V.

HOW I BUILT MY FIRST COIL.

HOW I BUILT MY FIRST COIL.

CHAPTER I.

REQUIREMENTS FOR BUILDING COIL, AND PRINCIPLES OF CONSTRUCTION.

Induced currents of electricity—Induction coil: how divided—Cost of making by amateur—Requirements for building coil—The reel: its ends—Core of reel —Cooling heated core, and dressing with paraffin—Putting ends on core—Covering core with paper—Winding on primary wire—Winding on secondary wire—Testing circuit—Soaking coil in paraffin—Casing coil with velvet—Base for coil—Hammer or contact-breaker—Platinum foil—Soldering platinum foil—Where to procure contact-breakers—Binding screws for base —Screwing coil to base-board—Attachment of spring—Connection beneath the base—Soldering wires to binding screws—Prices of wire, etc.—Handles for coil—Connection of battery with binding screws—Coil with regulating tube and condenser—The core: how to make it—Construction of base—Fixing the core—Mode of making condenser—Soldering tin foil in condenser —Board to secure condenser.

AMONG the many subjects which claim an amateur's attention in spare time, is electricity. This word is derived from the Greek word *elektron* amber, as its properties were first discovered in that substance Electricity is of two kinds—frictional and voltaic; but it is with voltaic that we have to deal just now in the form of induced currents. Induced currents are obtained from magneto-electric machines, coils, etc., by the making and breaking of the circuit many hundred times in a minute. We are greatly indebted to Messrs. Ruhmkorff, Hearder, Bentley, and others for the perfection to which they have brought the induction coil. The coil may be used for medical and scientific purposes, and also for amusement. The coil is divided into two parts, the primary and secondary In some of the scientific coils used for spectroscopic and other work, the secondary wire is 280 miles long. Much amusement can be got from a small coil, such as I am about to describe; and I do not think the amateur will grudge the money and time spent on one when he has finished it. It may also be used for medical purposes in cases of rheumatism, in

Induced currents of electricity.

Induction coil: how divided.

Cost of making by amateur.

the same way as the magneto-electric machine. Many cheap coils are being sold now-a-days, but I would not advise the amateur to buy one. A really good one costs from 15s. up to £9 or £10, according to size; but you can make a small one, with condenser, etc., for about 10s., which would cost 15s. or 20s. to buy it. I will now proceed to describe the coil.

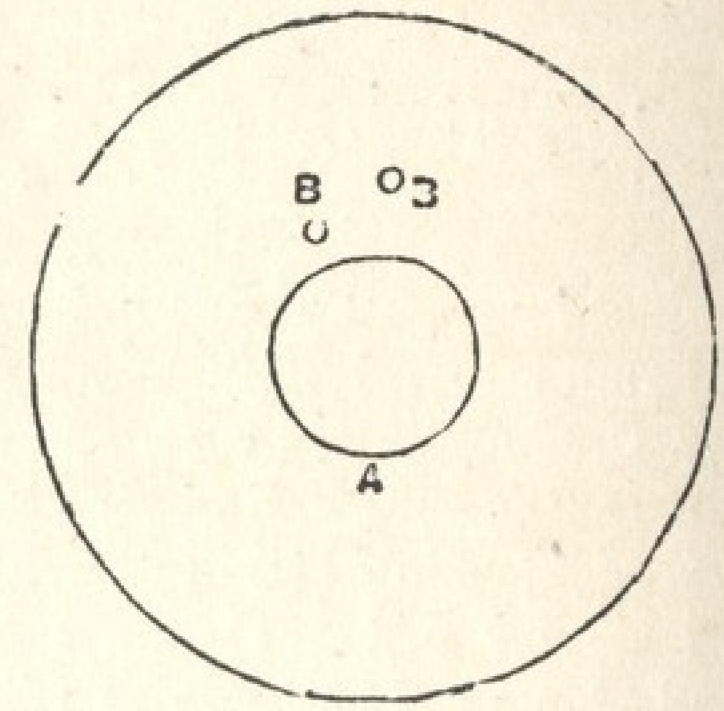


FIG. 1.—END OF REEL.
A, Hole for Core; B, B, Holes for ends of Primary Wire.

The requirements for building such a coil are not many, and are within the reach of every amateur. To make one of the dimensions I am about to describe, you will require one oz. of No. 24 cotton-covered wire, and two or three ozs. of No. 36 cotton or silk-covered wire (silk, of course, being preferable but more expensive), a bunch of annealed iron wire, a small piece of platinum foil and wire, four binding screws, and some pieces of brass, a piece of mahogany for a base-board and for ends to the reel, and a few tools, among which may be mentioned a soldering iron. Having given a general idea of what will be required, I will now proceed to give instructions for the manufacture of—

Requirements for building coil.

1. A coil without a regulating tube.
2. A coil with a regulating tube and condenser.

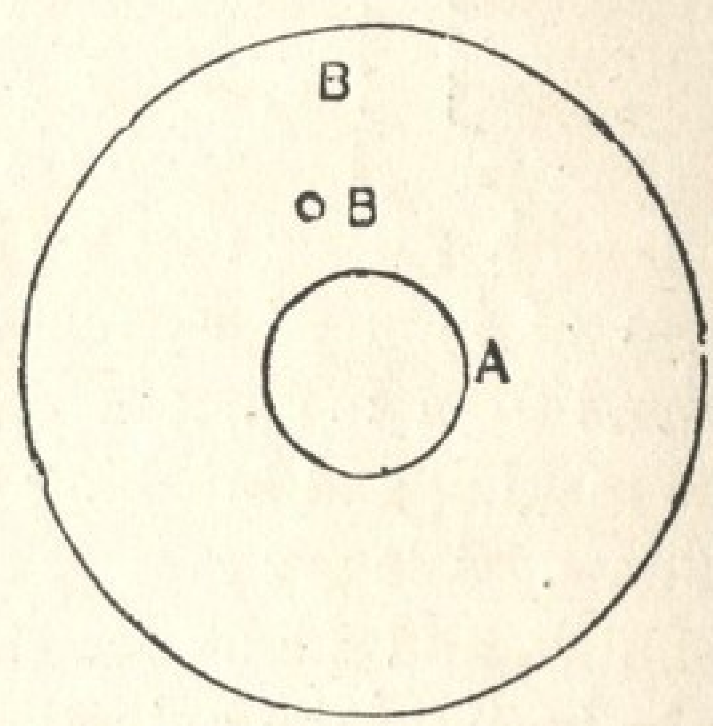


FIG. 2.—END OF REEL.
A, Hole for Core; B, B, Holes for ends of Secondary Wire

And, first of all, in order to make the reel, take a piece of mahogany about ¼ in. thick, and cut out two circular pieces 1¼ in. in diameter, as in Figs. 1 and 2. A hole is now drilled through the centre of these pieces ⅜ in. in diameter; this is to allow the core to pass through them. Two smaller holes are drilled in one of the pieces with a fine bradawl near the hole in the centre, as in Fig. 1; the second one being only about ⅛ of an inch from the centre hole. Two holes are also drilled in the other piece, as in Fig. 2. The next part is the core;

The reel: its ends.

it consists of a bunch of annealed iron wire cut into pieces $2\frac{1}{2}$ inches long. When you have cut them, straighten them out. Now get a brass tube $\frac{3}{8}$ inch *bore*, and pack all your wire into it, leaving about $\frac{1}{2}$ inch of the ends projecting out of the tube ; now take a piece of brass or very thin iron wire and wind it tightly round the end of the wires, always pulling them further out of the tube and winding until they are out altogether, when you must tie the wire you were winding with. It does not matter how they are wound if it is wound tight enough. Now take a file and file the ends of the core even and smooth. After you have done this, place the core, wire and all, in the fire until it is red hot (about 15 minutes will do), then lift it out with the tongs, and bury it among the ashes beneath the grate, and leave it there to cool of itself. Don't put it amongst water or you will spoil it. When cold, take it from among the ashes (it will take two or three hours to cool), blow off any dust which may be upon it, give it a gentle heat, and put it into your dish of melted paraffin. This is not the paraffin we burn in lamps, but a white substance resembling wax, and can be procured at any electrician's, or if you cannot get it, procure two or three pure paraffin candles and melt them in a dish. After it has been among the paraffin for about three minutes, take it out and allow it to drip above the plate. When it is hard you may proceed to finish the reel. Take off the wire you had round the core (it should now remain in a solid lump, like a small iron rod) and fix on the two pieces of wood, one at each end ; they should go on tightly if properly made ; leave about $\frac{1}{16}$ inch of the core projecting at one end : the other end should be flush, as in Fig. 3. Now take a piece of foreign note paper and cut a strip

Core of reel.

Cooling heated core, and dressing with paraffin.

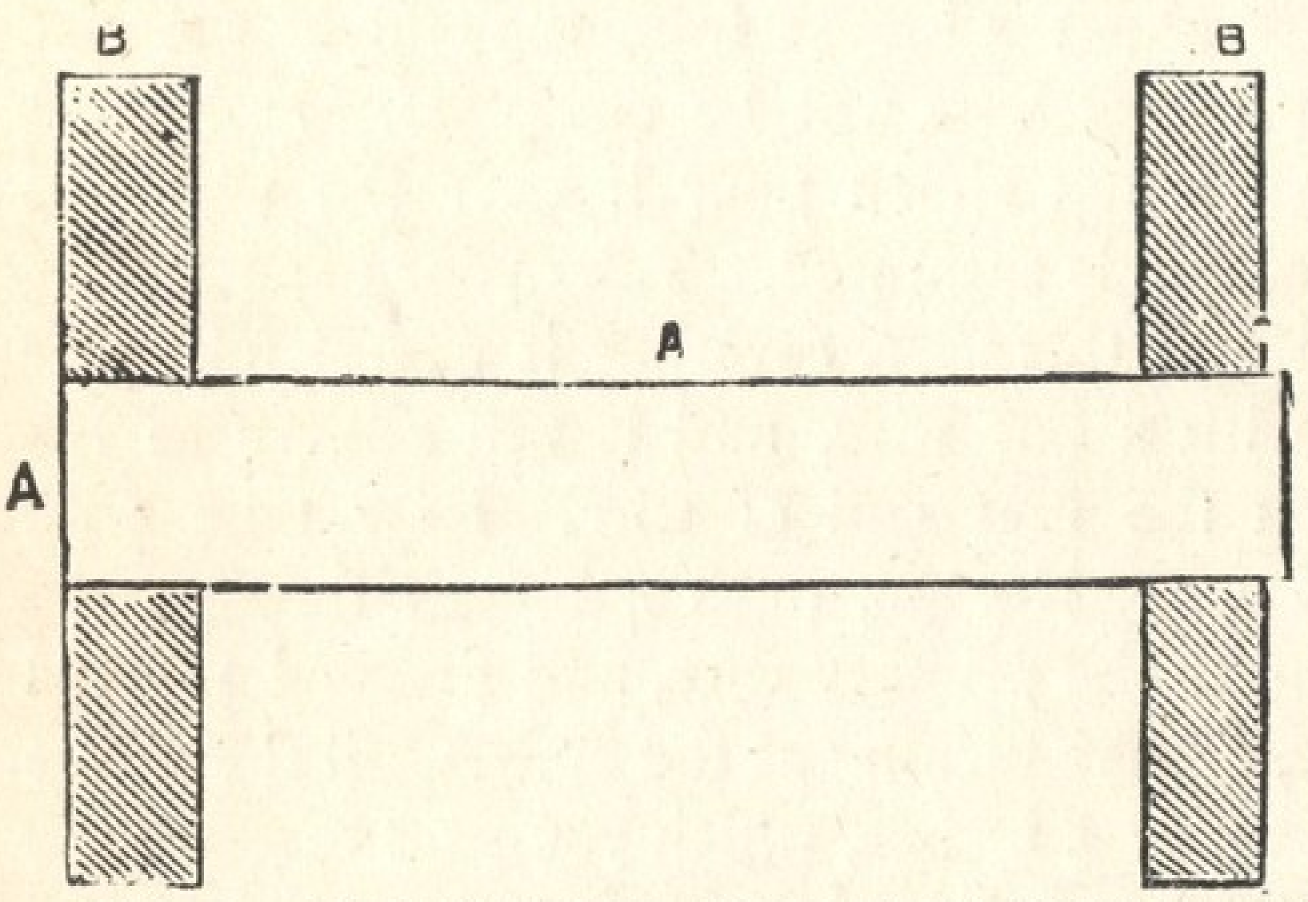


FIG. 3.—FORM OF REEL WHEN ENDS ARE PUT ON CORE.
A A, Core; B, B, Mahogany Ends.

Putting ends on core.

exactly the length of your core between the two ends. Then roll two thicknesses of it round the core, and cut off the rest. Melt a little paraffin over it to make it adhere tightly, and rub off the excess with a hot wire (not too hot). You will now be ready to wind on the wire. Take the thickest, No. 24, and pass about 3 inches of it out through one of the holes in the end where the core projects, and proceed to wind on the rest of the wire round the core (above the paper) in a close, even layer. When you reach the other end, wind it back above the first layer until you reach the end at which you started, then push the end through the other hole, and draw it out tightly. There will be a good bit of your wire left, but it will be useful. Cut the wire off about 4 inches from the end of the reel, and the primary wire will be complete. Melt your paraffin again, and with a hot spoon pour it over the wire you have wound until the cotton is saturated. Take your paper again, and put one thickness over this wire, covering it completely, give it a rub with a hot wire, and it will adhere to the paraffin on the first coil of wire. Now take your secondary wire, No. 36, push 4 inches through the hole in the opposite end to the primary wire, and proceed to wind as you did the primary, always turning at the ends, until the whole of it is wound on except 4 or 5 inches, which you pass through the hole above the other. The ends thus left are for connections. As this wire is very fine, great care must be taken in the winding, as it is easily broken. As an example of how to wind on the wire, it is wound in the same way as a reel of coton thread. Before proceeding further, you should see if the circuit is complete by joining the secondary wires to a battery and galvanometer, but take care you don't break them oft. Now melt your paraffin as before, but this time in a cup or jug, or anything in which it will cover the coil completely over head. Now place your coil in it, and set it down by the fire in a pretty hot place (not too hot for burning the cotton on your wire), and allow the paraffin to soak into it for about an hour, then take it out and allow it to drip. It should drip off the ends altogether, but if any remains scrape it off; but take care and don't cut off the ends of your wire, as the fine wire is very brittle. You now get a piece of velvet, any colour, cut a

Covering core with paper.

Winding on primary wire.

Winding on secondary wire.

Testing circuit.

Soaking coil in paraffin.

Casing coil with velvet.

strip the exact length of wire between the ends (as you did your paper) and as long as will go round the wire. It is then drawn tightly round and sewn with a thread. The velvet is to protect the wire and give a more finished look to the coil.

Base for coil.

The next part to be considered is the base. It is made of ½ or ¾ inch mahogany, and is 4 inches wide by 6 inches long; it is nicely planed, sand-papered, and polished; and, if possible, should have a nice ornamental border of about half an inch all round it.

Hammer or contact-breaker.

The hammer, or contact-breaker, will next engage our attention; it may consist either of a piece of sheet brass 1½ inch long by ⅜ inch, tapering up to ¼ inch at the point, as in Fig. 4, filed very thin so as to give it a spring, or a piece of the mainspring of a watch about ⅛ inch wide and 1½ long. To the small end of this spring is soldered a piece of soft iron, ⅜ inch in circumference and about ⅛ inch thick, as

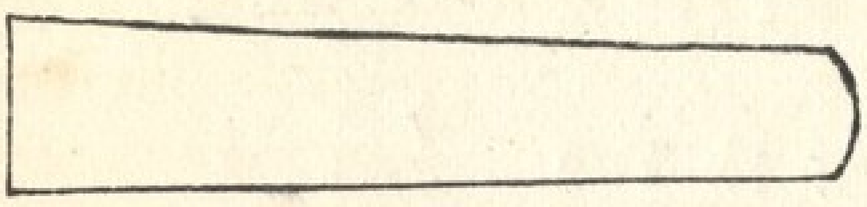


FIG. 4.—HAMMER OR CONTACT-BREAKER.

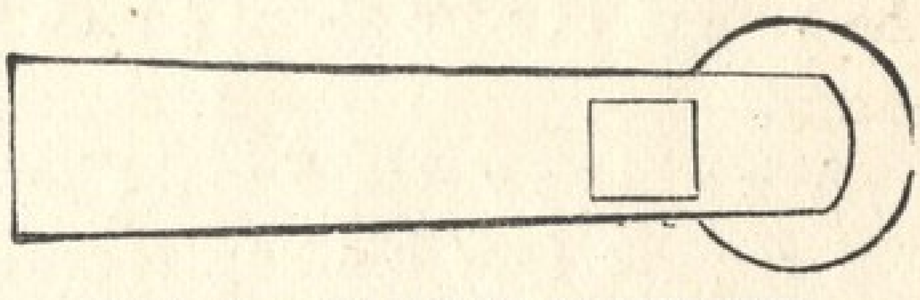


FIG. 5.—HAMMER COMPLETE.

shown in Fig. 5. A good substitute is the head of a nail such as is used for shoeing horses, cut off and filed to about ⅛ inch in thickness.

Platinum foil.

Your platinum foil will now be required. Cut off a small bit about ¼ inch square, and solder it to the back of the spring about ⅛ inch from where it joins the iron. You will notice that the iron is on the front of the spring, the platinum on the back, or opposite side. Great care must be taken in soldering on the foil as it is so thin. First put a little powdered resin on the place, lift a small particle of solder with your bolt, and spread it on the place where the platinum is to be. Now take your platinum, put it on the place and gently press it down with your bolt, when it should be firmly soldered to the brass. Perhaps it would be better to get a tinsmith to do this little job for you, if you know one. You must now take a piece of stout sheet brass, about 1½ inch long and ⅜ inch wide, and bend it at right angles, as in Fig. 6, so that A will be

Soldering platinum foil.

1 inch long and B ½ inch long. About ¼ inch from the top of A a hole is drilled and threaded so as to admit of a screw working in it. I may remark here that you can procure contact-breakers complete, tipped with platinum, and far better than you could make them, from any electrician; Messrs. H. and E. J. Dale supply them from 4s., but this would add to the expense. A common screw will not do here; a good substitute will be found in the screws that hold on gas and lamp glasses, and the part in which the screw works can be used when soldered to the brass strip A over the hole above-mentioned: this will save you the labour of getting a thread in the brass, it is also firmer. A hole is also bored through the part B to allow it to be screwed to the base. Now take the screw I mentioned as working in A, and drill a small hole in the point of it, to admit the end of the platinum wire. Now put in the end of your wire, carefully solder it to the screw, and cut off the excess of wire about ⅛ inch from the end of screw.

Where to procure contact-breakers.

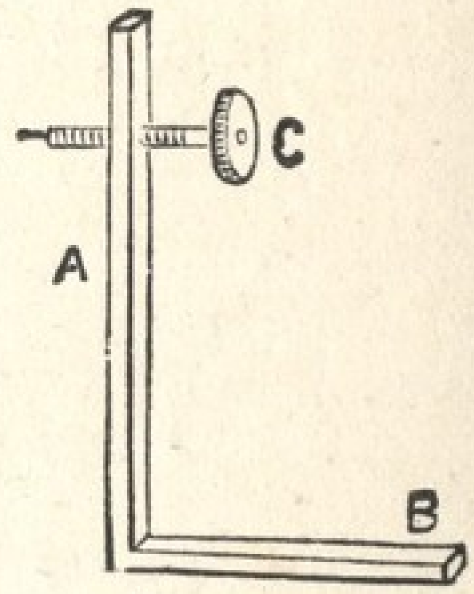


FIG. 6.—REGULATING SCREW.

We will now return to the base (Fig. 7). You will require four binding screws of small size. A hole is bored right through the base about ¾ inch from each corner, and the binding screws screwed into it. The coil is now to be screwed to the base-board, and for this you will require two small brass screws about ⅝ inch long, and as thin as you can get them. Now lay your coil on the top of the base-board, about 1¼ inch from one end and exactly in the middle (longways), mark the places and then remove your coil. Bore two holes right through the base, one at each spot where the coil rested. You now screw on your coil to the base, putting in the screws from the bottom of the base-board and driving them a short distance into the ends of the reel. Keep the end of the coil with the primary wire to the end marked A and the fine wire to B. Now bore two holes at each end close to the ends of the coil right through the base, and pass the free ends of your wire down through. You now take a piece of stout brass wire, or rod, about ¼ inch thick and 1 inch long, and, with a very fine saw, cut it down through the middle for ⅜ inch. Now bore a hole through the

Binding screws for base.

Screwing coil to base-board.

base at C in Fig. 7, so as to admit the wire tightly, put it in and push it down and through, leaving about $\frac{1}{4}$ inch above the base of the cut end. The point C is in exactly a straight line with the end of the coil and about $1\frac{1}{2}$ inch distant from the core, just about the edge of the base. Take the spring already referred to and insert the end of it in the cut in the piece of brass, it should be a very tight fit, and move it until you get the face of the iron head exactly opposite the core and about $\frac{1}{16}$ inch distant. Then take the piece of brass bent at right angles with the screw in it, and screw it on to the base with a round-headed screw about $\frac{3}{4}$ inch long, in such a way as that the platinum point of the screw (when the screw is about half screwed through) will just touch the centre of the platinum foil on the back of the spring, as in Fig. 8, and your coil will be finished except the connections. Of course if you buy a contact-breaker, as I mentioned, the fixing of it will depend on the style. Now turn your coil over so as to make your connections beneath the base, and it will be somewhat as in Fig. 9:—A, B, C, D, ends of binding screws; E, end of screw by which the back part of spring is screwed to base; F, end of rod with cut supporting spring; G and H, ends of primary wire; K, K, ends of secondary or fine wire.

Attachment of spring.

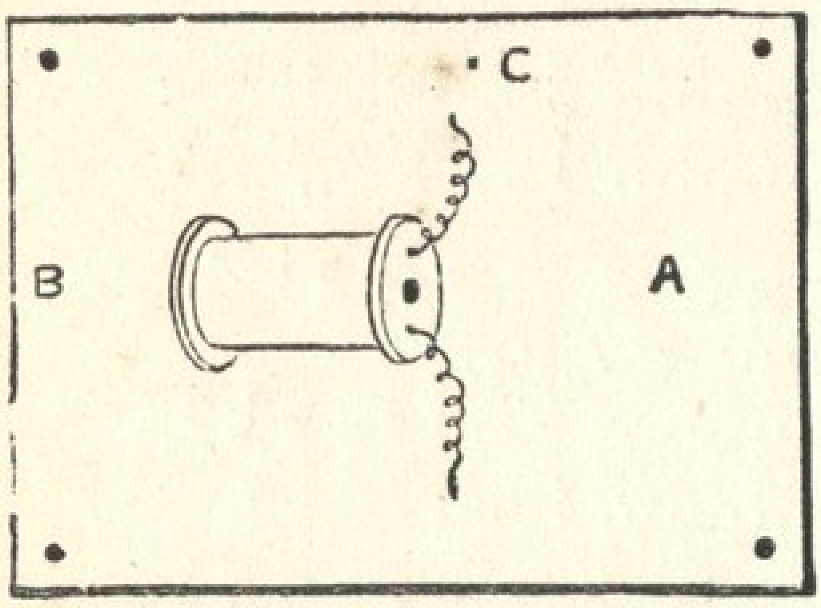


FIG. 7.—BASE OF COIL.

Connection beneath the base.

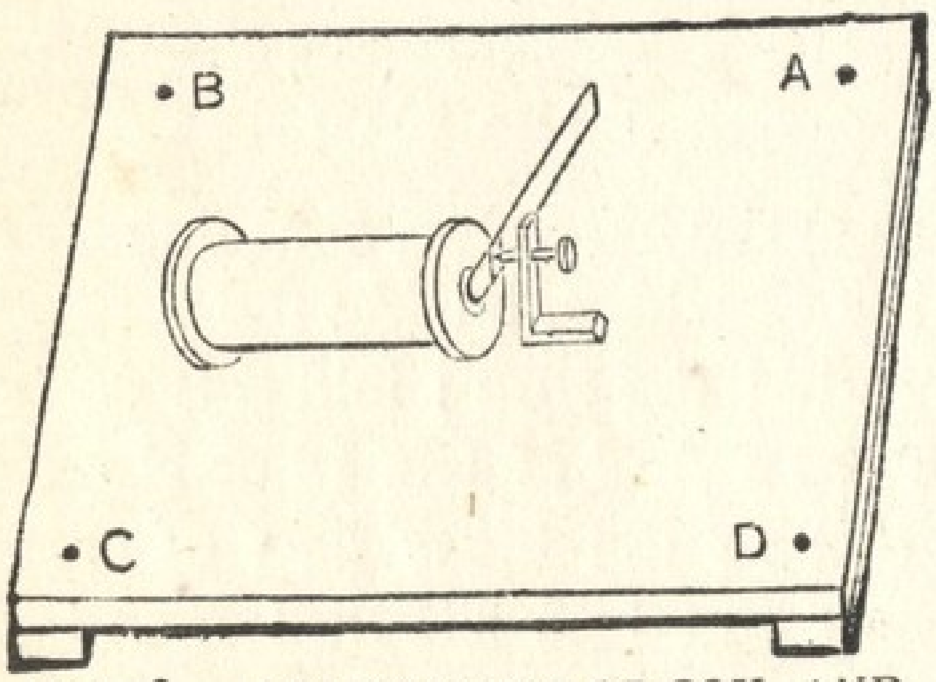


FIG. 8.—ADJUSTMENT OF COIL AND PLATINUM OF HAMMER.

Soldering wires to binding screws.

Now twist off the cotton from the ends of wires, K, K, and solder them to the ends of the binding screws, B and C. Next solder the end of wire G to binding screw A, and of wire H to the end of rod F; join D and E by a short piece of wire, soldering one end to each, and your coil will be complete except the handles and battery.

I subjoin a list of prices of wire, etc., which may be procured

from F. E. Becker & Co., of 33, 35, 37, *Hatton Wall, London, W.C.*, at about the following prices :—

Wire No. 24 cotton covered	....	3s. per lb.
" " silk "	....	5s. "
" No. 36 cotton "	....	8s. "
" " silk "	....	12s. "

Prices of wire, etc. Platinum wire and foil 1d. per grain, but 6d. worth of both (together) is enough.

Binding screws, with nut	....	3s. per dozen.
" " common	....	1s. 8d. "

Electricians and dealers in electrical apparatus supply :—

Contact-breakers	....	from 4s.
Regulating tubes	....	from 1s. 9d.
Cores, ready-made	....	from 1s. 6d.

The coil will now be complete except the handles. To make them, procure a pair of empty cartridges, large size, centre fire, with the caps extracted. Now take a pair of corks that will fit tightly into them, put a little gum or glue on the corks and force them in until they are flush with the end of the cartridge, taking care not to split the paper. Next cut a strip of tinfoil about ½ inch longer than the cartridge, coat one side with gum and roll it tightly round the cartridge, having the surplus half-inch at the end where you inserted the cork ; fold this down all round so as to hide the cork. Take a yard of No. 18 or No. 20 wire, and solder one end to the brass part of cartridge, and twist the loose end into a spiral round a ruler to make it take up less room. The other one is made in exactly the same manner. This finishes your coil, put the ends of the wires from your battery into binding screws A and D, Fig. 8, and the ends of your handle wires into B and C. Move your regulating screw C in Fig. 6 until you see a spark pass between it and the platinum of the hammer, and the coil will begin working, buzzing like a swarm of bees.

Handles for coil.

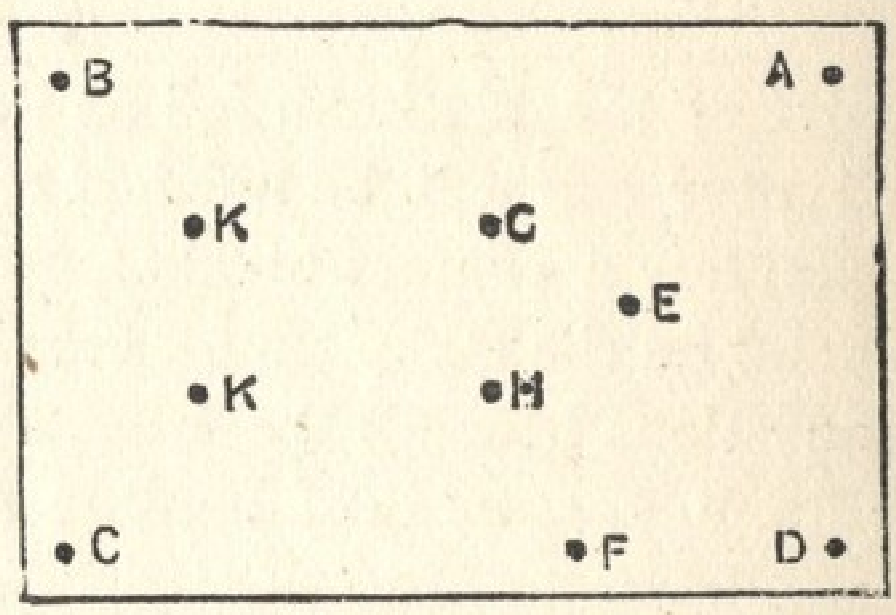


FIG. 9.—CONNECTIONS BENEATH THE BASE.

Connection of battery with binding screws.

We will now proceed to the description of a coil with a regulating tube and condenser. The ends are the same as in the other coil. Take a thin brass tube, such as is used for the barrel of a toy gun, $2\frac{5}{8}$ inches long by $\frac{3}{8}$ inch, and a strip of thin grey paper $2\frac{1}{2}$ inches wide. Cut it long enough to go twice round the brass tube, roll it once round, and mark it with a pencil where the paper meets. Take it off, and with your glue brush go over the remainder up to the marked line, then carefully roll it round your brass tube. You will now see that when the brass tube is withdrawn, the paper will form a tube of itself. Take the two ends of your coil, and glue one on to each end of the paper tube, and lay it aside to dry.

Coil with regulating tube and condenser.

The next part is the core, which is made in exactly the same way as mentioned before, only it is made this time to fit your brass tube, so that the tube may slide upon it. The wire is also wound in the same way as previously; but you must push your brass tube inside the paper one when you begin to wind, as the paper would collapse and be spoiled. The contact-breaker etc., are the same, so are also the connections of the wire under the base. The base itself is slightly different in construction although the same size. It is made of $\frac{7}{8}$ inch mahogany, with an ornamental border, and planed and polished as formerly. The bottom of it is hollowed out $\frac{1}{2}$ inch deep by $4\frac{1}{2}$ inches long by 3 inches broad, thus making a kind of box to receive the condenser.

The core how to make it.

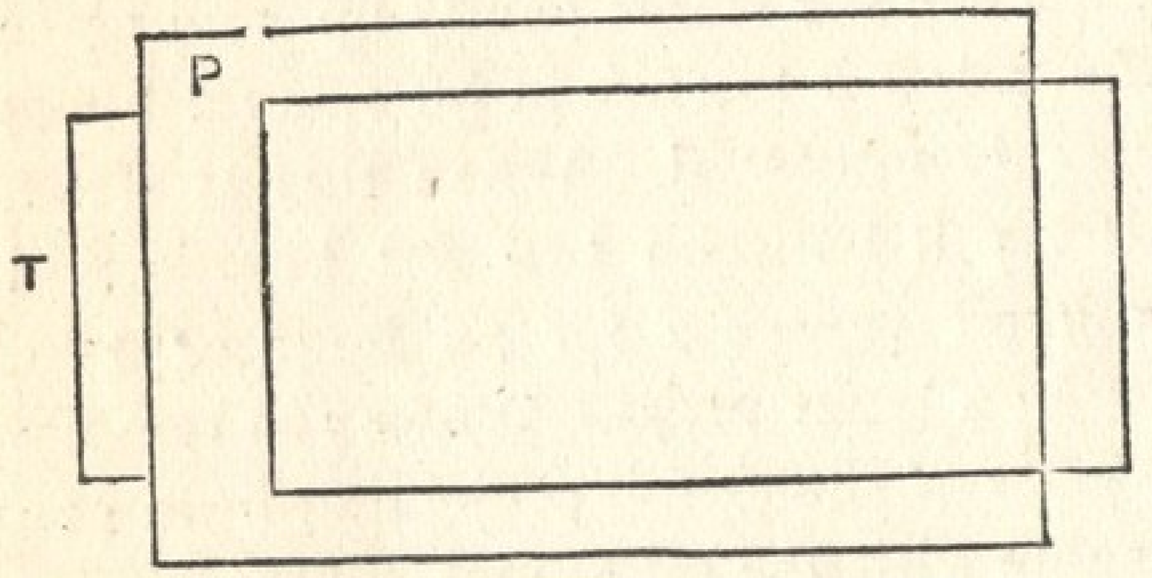


FIG. 10.—CONDENSER.

Construction of base.

The core is fixed into the inside of the paper tube with small pieces of wood about $\frac{1}{8}$ inch long, so that the brass tube will slide upon it. The brass tube has a small knob, or ring, soldered to one end so as to draw it out. The core projects at one end for the hammer to strike on, as previously mentioned, and the pins, which hold it firm, are first dipped in glue before insertion.

Fixing the core.

The condenser is now all that is required to finish. It is made of a number of sheets of grey paper and tinfoil alternately. The paper is cut $4\frac{3}{8}$ in. long by 3 in. broad, and the tinfoil $4\frac{3}{8}$ in. long by $2\frac{1}{2}$ in. broad. You will require about thirty of grey paper and twenty-five of tinfoil. Now take a sheet of paper and lay upon it a sheet of tinfoil, the foil projecting over one end about $\frac{3}{8}$ inch, then lay on a sheet of grey paper above this, and put a sheet of tinfoil upon it with $\frac{3}{8}$ inch of it projecting at the opposite end from the first one, as in Fig. 10, in which P is paper, T first tinfoil, F second tinfoil. Continue thus putting on the paper and tinfoil alternately, always making the projection at opposite end from the one you did last. So that at one end the tinfoil would run, if numbered, 1, 3, 5, 7, and at the other 2, 4, 6, 8, and so on, finishing, as you began, with a sheet of paper.

Mode of making condenser.

See that your paper is free from pin-holes. Cartridge drawing-paper is preferable to grey. Take the whole gently up and place it in a plate of melted paraffin, allow it to soak in for several hours until it is thoroughly saturated. When this is done, take it out and lay it between two flat boards and subject it to a good pressure for an hour or two, either under heavy weights or in a letter press. When you remove it, proceed to solder all the ends of the tinfoil projecting from one end to each other, and the same with the other end. This is very delicate work and your soldering-iron must not be too hot. Next solder a small piece of No. 20 wire about 3 inches long, one to each end of the foil. The other ends of these wires are soldered, one to connection E, Fig. 9, and the other to connection F under the base. An extra sheet of grey paper is placed on the top of the condenser, and it is then gently pressed into the box formed in the base. Take care that the surplus of the condenser wire does not touch any of the other wires.

Soldering tinfoil in condenser.

A piece of thin board is now placed over the bottom and screwed down, to prevent the condenser falling out. Four small wooden feet are glued to this, and your coil will be complete. A bichromate battery is the most convenient for driving a small coil.

Board to secure condenser.

THE END.

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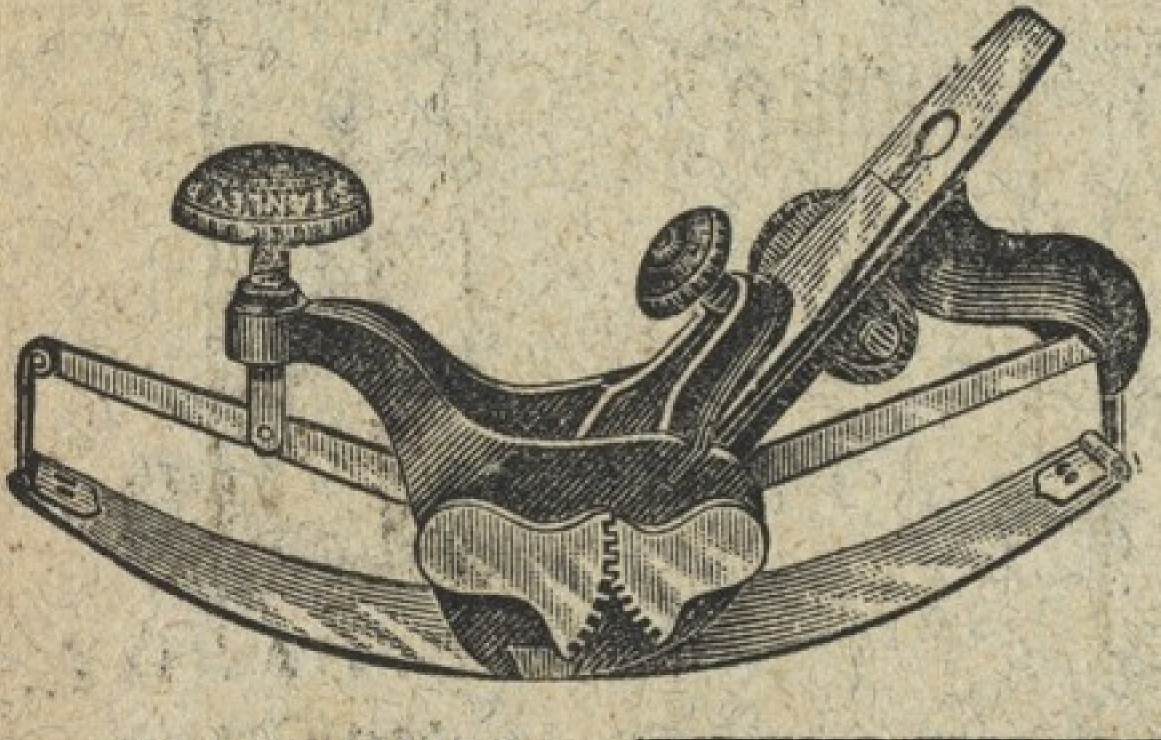

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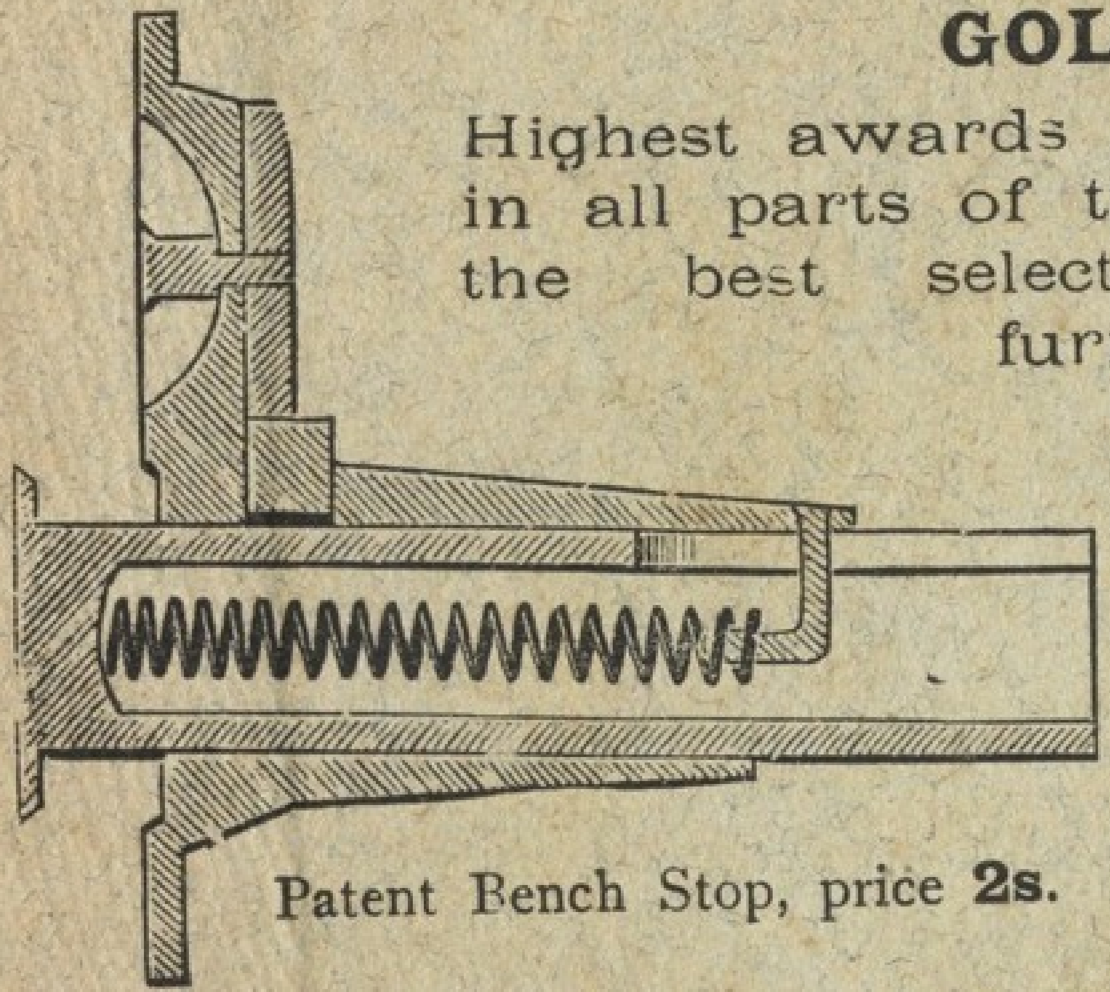

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